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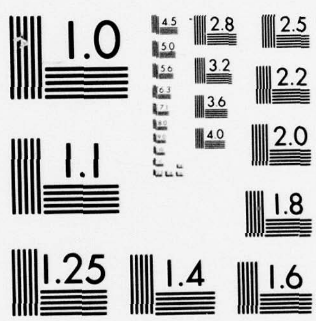

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AIR FORCE COMMUNICATIONS SERVICE

TRACALS EVALUATION REPORT

COMMUNICATIONS STATION EVALUATION REPORT

Ellsworth AFB, South Dakota

78/66C-122

27 March - 4 April 1978

AIR FORCE COMMUNICATIONS SERVICE

DEPARTMENT OF THE AIR FORCE
1866 Facility Checking Squadron (AFCS)
Scott AFB, Illinois 62225

5 May 1978

COMMUNICATIONS STATION EVALUATION REPORT

Ellsworth AFB, South Dakota

78/66C-122

27 March - 4 April 1978

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A Traffic Control and Landing Systems (TRACALS) Communications Station Evaluation was performed at Ellsworth AFB, South Dakota (2184 Comm Sq) from 27 March thru 4 April 1978. The purpose of the evaluation was to define the capabilities and limitations of the communications system servicing the radar approach control (RAPCON) and control tower. Included in this report are the results and analysis of equipment checks, system line-level diagrams, line-of-sight coverage data, analysis of airborne measurements of signal strength, and plots of UHF radiation patterns. Other items which are discussed in this report and are

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Block 20 ABSTRACT

common problems with most other systems, include system alignment procedures, and antenna maintenance problems. The data and diagrams in this report can be used as a guide for anticipated performance of the communications system at Ellsworth AFB until there is a deletion, addition, relocation of equipment, or a change in horizon profile which would effect the system. This report will remain valid after relocation of the transmitter site.

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1. SUMMARY

1-1. Ground/Air/Ground Communications System

a. Ground-to-Air Communications: Ground-to-air coverage extends well beyond the limits of the Ellsworth AFB air traffic control (ATC) mission area. Coverage is adequate at all minimum vectoring altitudes (MVA) within the Ellsworth Control Area. The transmitter facility is scheduled to be relocated to a site near the receiver site. To gain an accurate picture of the coverage to be expected after the relocation, airborne checks were done from the receiver site using a spare UHF transmitter. The data collected illustrates that communications coverage will be adequate after relocation of the transmitter facility.

b. Air-to-Ground Communications: Air-to-ground communications was adequate for the Ellsworth ATC mission. The coverage exceeded predicted values for all quadrants.

c. Audio System Alignment: A high noise level in the air traffic controllers' headsets was present when the input to the regulated output amplifiers (ROA) was set for -35 dBm. When the input was set for -10 dBm the noise diminished. A local telephone company compression amplifier is located between the console and the ROA. This device amplifies the noise generated in the RAPCON to a level within the input range of the ROA. Setting the ROA input to -10 dBm reduces this problem and improves the quality of communications.

d. Radio Frequency Interference (RFI) at Receiver Site: Numerous low frequency signals (below one MHz) were measured in the receiver building. These signals contributed to high noise levels measured in the receiver when the RF input was low. When the RF input is -90 dBm or greater, the noise diminishes.

e. RAPCON Backup Radio Antenna Tower: The RAPCON backup radio antenna tower causes one degree of screening for the local weather radar. A proposed lowering of the tower 20 feet to eliminate the radar screening will significantly increase the radio line-of-sight screening for the approach end of runway 13 and will cause a decrease in coverage for that area.

f. AT-197/GR Antenna: During the evaluation, the antenna in use was an AT-197/GR antenna. This antenna provides increased coverage at low takeoff angles compared to the AS-1097/GR antenna. At the altitudes flown during the evaluation, the AT-197/GR has 11 dB more gain than the AS-1097/GR.

1-2. Power Systems: Primary and backup power systems for all facilities were adequate and reliable.

2. RECOMMENDATIONS

2-1. Ground/Air/Ground Communications System

a. Recommend the AT-197/GR antenna be utilized rather than the AS-1097/GR (see para 4-5a).

b. Recommend the input to the ROA be tested at -10 dBm rather than -35 dBm (see para 4-5c).

c. Recommend that maintenance personnel use the evaluation team's system alignment procedures until the technical order change is received (see para 4-5c).

d. Recommend that an RFI team be requested to investigate the source of the low frequencies causing noise in the receiver site (see para 4-5d).

e. Recommend that careful consideration be given to the increased screening resulting from the proposed lowering of the RAPCON backup radio antenna tower (see para 4-5e).

2-2. Power Systems: No recommendations.

3. GENERAL INFORMATION

3-1. Facility Data

a. General

Location: Ellsworth AFB, South Dakota
Communications Area: SACCA
Unit: 2148 Communications Squadron
Evaluation Period: 28 March - 4 April 1978

b. Communications

Control Tower Coordinates: 44° 08' 44" N
103° 05' 39" W
Control Tower Site Elevation: 3212 feet MSL
RAPCON Coordinates: 44° 08' 44" N
103° 05' 35" W
RAPCON Site Elevation: 3212 feet MSL
Transmitter Site Coordinates: 44° 08' 41" N
103° 07' 39" W
Transmitter Site Elevation: 3235 feet MSL
Receiver Site Coordinates: 44° 08' 01" N
103° 06' 02" W
Receiver Site Elevation: 3194 feet MSL
Receiver Antenna Height: 80.5 feet AGL

3-2. Runway Data

Airfield Coordinates: 44° 08' 30" N
103° 06' 30" W
Airfield Elevation: 3276 feet MSL
Magnetic Declination: 13° E

3-3. Mission Area

a. The Ellsworth Terminal Control Area is that airspace extending from the surface up to and including 12,000 feet MSL within a 40 NM radius of the Ellsworth TACAN (see TAB A-1).

b. The Ellsworth Control Zone is the controlled airspace which extends from the surface up to and including 12,000 feet MSL. Its boundaries are described as a five statute mile radius of the geographic center of Ellsworth AFB with a 2.5 mile extension on either side of the Ellsworth TACAN 116 radial extending to 7 miles and 8 miles respectively. These extentions are needed to provide controlled airspace to include instrument approach and departure paths.

3-4. Mission Responsibility: The Ellsworth RAPCON is responsible for providing terminal air traffic service within its area of control, which includes Rapid City Regional Airport and many other small airports. The Ellsworth AFB Control Tower is responsible for providing control of visual flight rules (VFR) air traffic in its control area. Flying at Ellsworth AFB is moderate to heavy.

3-5. Primary Using Agency/Aircraft Supported: The primary operational user of Ellsworth AFB is the 28 Bombardment Wing flying B-52s. Many types of commercial and military aircraft use the base.

3-6. ATC Facilities

a. RAPCON

(1) AN/FPN-47 Airport Surveillance Radar

(2) AN/TPX-42 Air Traffic Control Radar Beacon System

(3) AN/FPN-16 Precision Approach Radar

(4) Four Channel Communications Control System/301A Key System

b. Control Tower

(1) AN/GSA-135 Console

(2) Four Channel Communications Control System/302A Key System

(3) Bright Radar Indicator Tower Equipment

c. NAVAIDS

(1) AN/GRN-27 Solid State Instrument Landing System

(2) AN/GRN-19A Tactical Air Navigation

3-7. Logistic Support: Logistic and precision measuring equipment laboratory support is provided by the host base.

3-8. Key Personnel

a. Ground Evaluation Personnel

1Lt A.C. Mathews, Team Chief/Electrical Engineer
MSgt W.V. Rogers, NCOIC, TRACALS Evaluation Team
SSgt P.A. Tovar, TRACALS Communications Evaluator
Sgt R.J. Herrera, TRACALS Communication Evaluator
SrA S.F. Jurash, Geodetic Surveyor

b. Airborne Evaluation Personnel

Capt L.R. Duncan, Aircraft Commander
Capt J.E. Lawrence, Pilot
MSgt F.F. MacMahon, Flight Inspection Technician
SSgt M.J. Aufieri, Flight Inspection Technician
TSgt F.H. Hutchinson, Jr., Flight Mechanic

c. Facility Personnel Contacted

LtCol J.W. Cowan, Commander
Capt. S.J. Geertz, Chief of Maintenance
Capt. J.J. Hayden, Chief, ATC Operations
1Lt B.P. Heseltine, Chief Controller, RAPCON
CMSgt J.L. Mallard, Chief Controller, Control Tower
SMSgt D.W. Schroeder, Maintenance Superintendent
MSgt J.W. Knight, NCOIC Radio Maintenance
SSgt J.M. Nielson, NCOIC Radar Maintenance

4. GROUND/AIR/GROUND COMMUNICATIONS SYSTEM

4-1. System Description: Air traffic control communications at Ellsworth AFB are provided by remotely controlled VHF/UHF radio equipment. Landlines interconnect the remote transmit and receive radio facilities with the RAPCON and control tower. A four channel communications control system is used to provide keying, amplification and control of the transmit and receive audio signals to and from the remote facilities. The communications antennas are mounted approximately 80 feet above the ground on steel towers. Each control facility has its own backup radio equipment.

VHF/UHF Radio Equipment	Qnty	Freq (MHz)	Use
AN/GRT-21 Transmitter	10	119.5	RAPCON Primary
AN/GRT-22 Transmitter	19	121.1	Clearance Delivery
AN/GRR-24 Receiver	19	121.5	Emergency
AN/GRR-25 Receiver	10	125.3	RAPCON Discrete
AN/GRC-171 Transceiver	2	126.2	Control Tower Primary
AN/GRC-175 Transceiver	2	134.1	RAPCON Discrete
		236.6	Control Tower Discrete
		243.0	Emergency
		253.5	Control Tower Primary
		259.1	RAPCON Discrete
		271.3	RAPCON Primary
		272.2	RAPCON Discrete
		275.8	Control Tower Ground Control
		284.0	RAPCON Discrete
		289.4	Clearance Delivery
		363.8	RAPCON Discrete
		375.2	RAPCON Discrete
		390.8	RAPCON Discrete
		396.0	RAPCON Departure

Ancillary Equipment	Qnty	Use
CU-547/GR	5	Antenna Coupler
AN/GSA-135	1	Control Tower Console
Four Channel/302A Key System	1	Control Tower
Four Channel/301A Key System	1	RAPCON
AT-197/GR	17	UHF Antenna
AS-1097/GR	2	UHF Antenna
AS-1181/UR	16	VHF Antenna

4-2. Equipment Status

a. Facility Equipment Status: Equipment checks were accomplished using procedures described in the equipment technical orders. Where no procedures are given, AFCSP 100-61, Vol XIII was used as a guideline to ascertain the operational status of the equipment. The equipment specifications and test results are shown in TABs E-1-1 thru E-5-4.

(1) Transmitter Site: Four of the transmitters checked had high output power and two had modulation in excess of 100%. One transmitter checked had high distortion which was corrected by adjustment. All of the ports on one antenna coupler had high insertion loss which could not be corrected externally.

(2) Receiver Site: Three of the receivers checked had incorrect signal-to-noise ratios. All but one of the high noise conditions were corrected by receiver alignment. The other receiver would not tune to specifications. One receiver had a low audio output which was corrected. Only one antenna was found to be defective during the evaluation and this antenna was replaced by the squadron antenna team. One spare antenna cable had no markings. Investigation revealed that no antenna was connected to the cable.

4-3. <u>Environmental Factors</u>

a. Siting Characteristics:

(1) General: Ellsworth AFB is located on the extreme western side of the state of South Dakota about 10 miles east of Rapid City. The Black Hills are approximately 25 miles to the west and form the only significant screening in the area. The terrain to the south, east and north is generally rolling prairie.

(2) Transmitter Site: The transmitter site is located southeast of the approach end of runway 13. The terrain surrounding the site is primarily flat, treeless pasture land.

(3) Receiver Site: The receiver site is located northeast of the approach end of runway 31 on terrain identical to that surrounding the transmitter site.

b. Weather

(1) Surface Climatology: The climate of Ellsworth AFB is characterized by short summers and long, moderately cold winters. Cold waves usually occur about five times each winter with varying severity, but they are not prolonged as a rule. They are often broken up by warm and pleasant weather, usually brought on by the onset of chinook winds Precipitation amounts to about 16 inches annually, while the mean annual snowfall is 38 inches. Snow has occurred in every month except July and August.

(2) Propagation Climatology:

(a) During the winter Ellsworth AFB is primarily dominated by continental polar (cP) air masses. This cP air often moves upslope into the area around the southwest periphery of the Canadian cP high pressure outbreaks. In the early part of the season, before the

ground is snow covered, slightly subrefractive conditions will exist during daylight hours, while at night conditions will become standard to slightly superrefractive by early morning. Later in the season, as snow covers more of the surface, conditions become more conservative, remaining mostly standard to slightly subrefractive. However, on nights with clear skies and calm winds, radiational cooling will create a low level temperature inversion and moderate superrefractive conditions will occur. Strong surface winds that develop shortly after sunrise and are predominant in this area, cause rapid vertical mixing to moderate levels and destroy surface and low level ducts that may have been formed by nocturnal cooling. Also, during this season the warm chinook winds pick up moisture in the lower levels from melting snow creating conditions favorable for ducting. Due to surface mixing and turbulence, these ducting layers which are often strong, are formed at the top of the convective levels near 1000 to 2000 feet. These ducts will persist for the duration of the chinook. Maritime polar (mP) air moving into this area from the Pacific has been dried out and warmed in coming over the mountains. It is warm compared to the cP air present in the area and is forced aloft over the cooler cP air. A subrefractive layer is usually formed at the mixing zone of these two air masses.

(b) During the summer months maritime polar (mP) air is the predominant air mass in this area. Although normal propagation can be expected to occur the majority of the time, this is also the season of maximum superrefractive activity. The maritime polar (mP) highs moving in from the Pacific frequently have inversions, due to subsidence, up to 10,000 feet. The effects of chinook winds form inversions 1000 to 2000 feet above the surface. These inversions are favorable to the formation of superrefractive layers. Often nocturnal cooling creates favorable conditions for the formation of moderate to strong superrefractive layers near the surface. These conditions will persist until some change of weather regime occurs.

(c) In the spring and fall propagation conditions become standard to slightly subrefractive. These seasons are transitional periods between the more frequent superrefractive conditions of summer and the standard to subrefractive conditions of winter.

(d) The charts "Frequency of Refractive Conditions in Percent" (TAB G-1) are derived from summaries of atmospheric refractive indexes prepared by the USAF Environmental Technical Applications Center (AWS). They are computed for the nearest rawinsonde station considered to be representative of this site. The charts represent a count by month, over the period of record of three or more years, of the minimum gradient category in percent frequency of occurrence. Only the one minimum gradient category in each upper air sounding has been counted. For this reason subrefraction is seldom shown on the charts, as more negative gradients will usally be found and counted. A discussion of refractive theory, and a description of the refractive index categories and their corresponding gradients in N-units per 1000 feet is found in TABs G-2-1/2.

(3) Evaluation Weather Conditions: Weather did not adversely affect the airborne data collection phase of the evaluation. During the flying days there was good mixing action in the atmosphere resulting in ideal electromagnetic propagation conditions.

4-4. Evaluation Profile: The overall objectives of the evaluation were to define the capabilities and limitations of the air traffic control communications equipment in the installed environment and to optimize the performance of the system. These objectives were met by making the siting and environmental studies discussed in paragraph 4-3 and performing the equipment, system, and airborne checks described below.

a. Ground Tests: Ground tests were performed prior to the airborne tests. They consisted of two types: equipment checks and loop tests.

(1) Equipment Checks: Equipment checks were performed prior to loop and airborne tests to ensure proper operation of major end items. The results of the checks were compared with technical order specifications. Where technical order specifications were not listed, the data base built from prior evaluations was used as a reference in determining equipment performance. Additional information, such as antenna placement measurements (TABs D-1-1/2), was also obtained. Adjustments of equipment for optimum operation were made immediately, if possible without extensive maintenance. Other problems were identified to maintenance personnel for correction. The corrected readings are included in the "adjusted" column of the equipment check forms. The audio amplifier measurements were recorded after the amplifiers were adjusted for normal operation.

(2) Loop Tests: Loop tests were utilized to evaluate the system performance of the previously tested end items. An operational position in the RAPCON and a maintenance position in the control tower were used for the loop tests. A one kHz tone was injected into the microphone amplifiers for simulation of a normal voice input. One frequency at a time was keyed. The signal levels, signal-to-noise, and modulation measurements were taken on the transmit portion of the system with a dummy load placed on the transmitter. The one kHz tone was removed and noise and carrier power measurements were taken. The audio measurements were taken on the receiver side of the system using a 30 percent modulated RF carrier connected to the input of the receiver equipment. The audio measurements were taken at accessible points in the system. The resulting data were used to determine the signal levels presented on the Loop Test Line Level Diagrams (TABs E-3-4 and E-4-6).

b. Airborne Tests: The airborne tests were accomplished using a C-140A flight inspection aircraft flying radials and orbits off the Ellsworth TACAN. The automatic gain control (AGC) current of the airborne receiver was used to obtain the receive signal level (RSL) of

the communications frequency under test. Fourteen radial tracks and one orbit were flown using the aircraft receiver to measure the ground-to-air transmit signal strength; eight radial tracks and one orbit were flown using a ground receiver to measure air-to-ground transmit signal strength (see TAB F-1). Radial track measurements were used to determine vertical radiation patterns, and orbital tracks were used to determine horizontal patterns. Prior to the airborne tests, the aircraft and ground receiver AGC currents were calibrated in dBm by injecting known signal levels into the receiver's RF transmission line and annotating the strip chart recordings. The ground transmitter was continuously keyed with the output power set at 10 watts. The aircraft transmitter output was measured and recorded. While measuring the air-to-ground signal strength the aircraft transmitter was keyed on and off at ten seconds intervals.

4-5. Analysis of Evaluation Results

a. Ground-to-Air Communications: AFM 55-8 tolerances specify clear and readable communications at altitudes which meet operational requirements at a minimum distance of 15 NM for the control tower and 30 NM for approach control. Emergency communications is desired to extend as far as possible. Pilot-to-Forecaster communications is required to 100 NM at 20,000 feet above the site elevation (AWSR 105-12). The RSL measurement flight profile is shown in TAB F-1 and the results of the ground-to-air signal strength measurements are contained in TABs F-2-1/2. The data from the orbits and radial tracks give a composite three dimensional picture of the electromagnetic radiation pattern of the antennas under test.

(1) Horizontal Radiation Pattern: The orbit was flown at a radius of 30 NM and an altitude of 9600 feet MSL. The RSL was relatively constant throughout the orbit. This was due to the flat, treeless, uniform terrain encompassing the base. The mean RSL was -75 dBm utilizing an AT-197/GR antenna. This value well exceeds the predicted value of -93.2 dBm. The predicted value is derived from theoretical calculations which utilize antenna gain at specific takeoff angles, frequency, transmission line losses, distance, and output power. Antenna gain values come from manufacturer's data for the AS-1097/GR antenna. Utilizing antenna gain values for the AT-197/GR antenna, the predicted RSL is -82.0 dBm. At the altitude and range for the orbits, the takeoff angle was 1.85 degrees. The AS-1097/GR antenna has a gain of -9 dBi at this takeoff angle, whereas the AT-197/GR has a gain of +2.15 dBi. The AS-1097/GR is the antenna in use at most ATC remoted transmitter and receiver sites and is in use at Ellsworth. The predicted RSL for an AS-1097/GR at the altitude flown and at 30 NM out would be 0.2 dBm below the squelch threshold of the aircraft's receiver. The calculations do not take into account multipath propagation, weather, screening, or other environmental factors. The improved antenna radiation pattern of the AT-197/GR, flat terrain (which induced multipath and presented no screening), and excellent weather conditions accounted for the better than predicted RSLs.

(2) Vertical Radiation Pattern: TABs F-3-1/6 show that coverage extended beyond the Ellsworth Control Area, exceeding 50 NM in all quadrants at the MVA. Due to the AT-197/GR antenna radiation pattern and environmental factors, radial coverage is extended compared to that normally found at sites utilizing the AS-1097/GR antenna. The aircraft's nose high attitude in flight produces an approximate five dB difference between outbound and inbound tracks. The effects of multipath radiation were evident when analyzing the chart recording taken on the 050° radial. The signal level varied almost sinusoidally, indicating the addition and cancellation of the signal due to reflections (multipath). The signal path was directly across the runway, taxiways, and ramps on the 050° radial. These flat, concrete surfaces, when combined with the flat, treeless terrain of the base, are excellent reflective surfaces, thus producers of multipath radiation.

(3) Screening Effects: The only significant screening at Ellsworth is the Black Hills to the west. There is no significant on-base screening of the communications system, except as noted for the RAPCON backup radios (see para 4-5e).

(4) Relocation of Transmitter Site: Scheme action is anticipated to begin late this year to relocate the transmitter site. The new site will be in building 6925 which is approximately 100 yards from the present receiver site (building 6922). To provide data which will be useful in the future, a spare UHF transmitter was set up in the receiver site. This transmitter was utilized during the ground-to-air portion of the evaluation. No VHF transmitter was available, therefore no VHF tracks were flown. VHF coverage will extend significantly further than UHF coverage. The longer wavelength propagates further than the shorter wavelength of UHF. Due to the close proximity of the present receiver site to the new transmitter site, the use of a transmitter at the receiver site gave an accurate presentation of ground-to-air communications coverage after relocation.

b. Air-to-Ground Communications: Air-to-ground coverage normally exceeds ground-to-air coverage. Radial data generally supports this, however, the mean RSL for the air-to-ground orbit was -82 dBm. This lower reading is due to the use of an antenna multicoupler with its 2 dB of loss, and other environmental factors. No coupler was in use during the ground-to-air phase of the evaluation. The -82 dBm mean RSL is 15.5 dB above the squelch threshold of the ground receiver. As a result, communications coverage extends beyond the limits of the Ellsworth Control Area.

c. Audio System Alignment: Some alignment procedures utilized for the four channel communications control system in the RAPCON specify testing the ROA with an input of -35 dBm. When the ROA is set for this input, the controllers experienced high noise in their headsets, making

communications difficult to impossible. A local telephone company (TELCO) compression amplifier is located before the ROA. This causes background noise and voice signals to arrive at the ROA at similar levels. Maintenance personnel are not able to adjust the TELCO's compression amplifier. If possible, the TELCO compression amplifier should be used solely as an amplifier, if amplification is felt necessary prior to the ROA. Another option would be to adjust the compression amplifier to eliminate background noise with an audio threshold adjustment, if one is present. Due to the presence of the TELCO compression amplifier, the ROA must be tested with an input of -10 dBm rather than other levels mentioned in some instructions. Change 5 to TO 31Z3-220-6WC-1 will include alignment procedures for the four channel communications control system which will specify the input to the ROA be set at a level providing the best possible communications. Until receipt of this change, maintenance personnel can provide optimum communications utilizing the evaluation team's alignment procedures.

d. Radio Frequency Interference at Receiver Site: High noise at the receivers' output was noted during the loop tests. This noise is evident when the RF input is at 3 uV (squelch threshold), and diminishes as the RF input to the receiver is increased. At the low input level internal receiver noise appears. As the RF signal level is increased the signal to-noise ratio increases. Investigation into the cause of this noise using a spectrum analyzer showed a number of distinquishable frequencies inside the receiver building. These frequencies were predominantly in the low frequency range (below one MHz). The data in TAB E-4-1 was taken when the RF input was greater than 3 uV which corresponds to -97.5 dBm at 50 ohms. Measured RSLs were significantly greater than -90 dBm, thus the RFI does not seriously effect communications, except when RSLs are very low.

e. RAPCON Backup Radio Antenna Tower: The RAPCON backup radio antenna tower causes one degree of screening of the local weather radar pattern. The radar tower is approximately 50 yards south and at the same elevation as the radio tower. A scheme has been proposed to correct this by lowering the radio antenna tower 20 feet. Screening data (TAB B-2-4) shows that if the radio tower was lowered 20 feet, screening for the radios would increase. From 317° to 329° the screening angles would increase from +0.5° to +1.4°. Between 329° and 339° the screening angles would increase from 0° to +0.9°. The distance to the horizon would decrease from 15 miles to less than one mile. The Pride hangar (Building 7504) is the object causing this screening. The metal catwalk on the hangar's roof causes 0.5° of screening (from +0.9° to +1.4°). The approach end of runway 13 will be affected. Due to this screening angle an aircraft must be 150 feet off the ground for radio line-of-sight communications between 317° and 329° at one mile. The control tower (between 268° and 273°) will still be below the horizon and will not create additional screening for the runway if the antenna tower is lowered.

4-6. Capabilities and Limitations

a. Ground-to-Air Communication: Ground-to-air communications coverage extends beyond the limits of the Ellsworth Control Area at the MVA. Relocation of the transmitter site will not cause any decrease in coverage. Screening is not a factor. Multipath propagation is the only noticeable influence on coverage.

b. Air-to-Ground Communication: Air-to-ground communications coverage extends beyond the Ellsworth Control Area at the MVA. The effects of multipath is the only influence noticed. Screening did not affect the communications coverage.

c. Predictions: During normal operation, communications will continue to adequately serve the Ellsworth ATC mission area. The relocation of the transmitter site will ease maintenance and not affect the coverage. Environmental factors, weather and multipath, will influence the communications, but will not degrade it below desired levels, except under extraordinary conditions. Backup communications for the RAPCON will be affected by screening if the proposed lowering is accomplished. This screening will be evident on the approach end of runway 13.

5. POWER FACILITIES

5-1. Equipment Details: Commercial power is provided for the RAPCON, control tower, transmitter, and receiver sites. Secondary power is provided by backup generators for each facility. A detailed list of the equipment and test results are presented in TABs E-5-1 thru E-5-4.

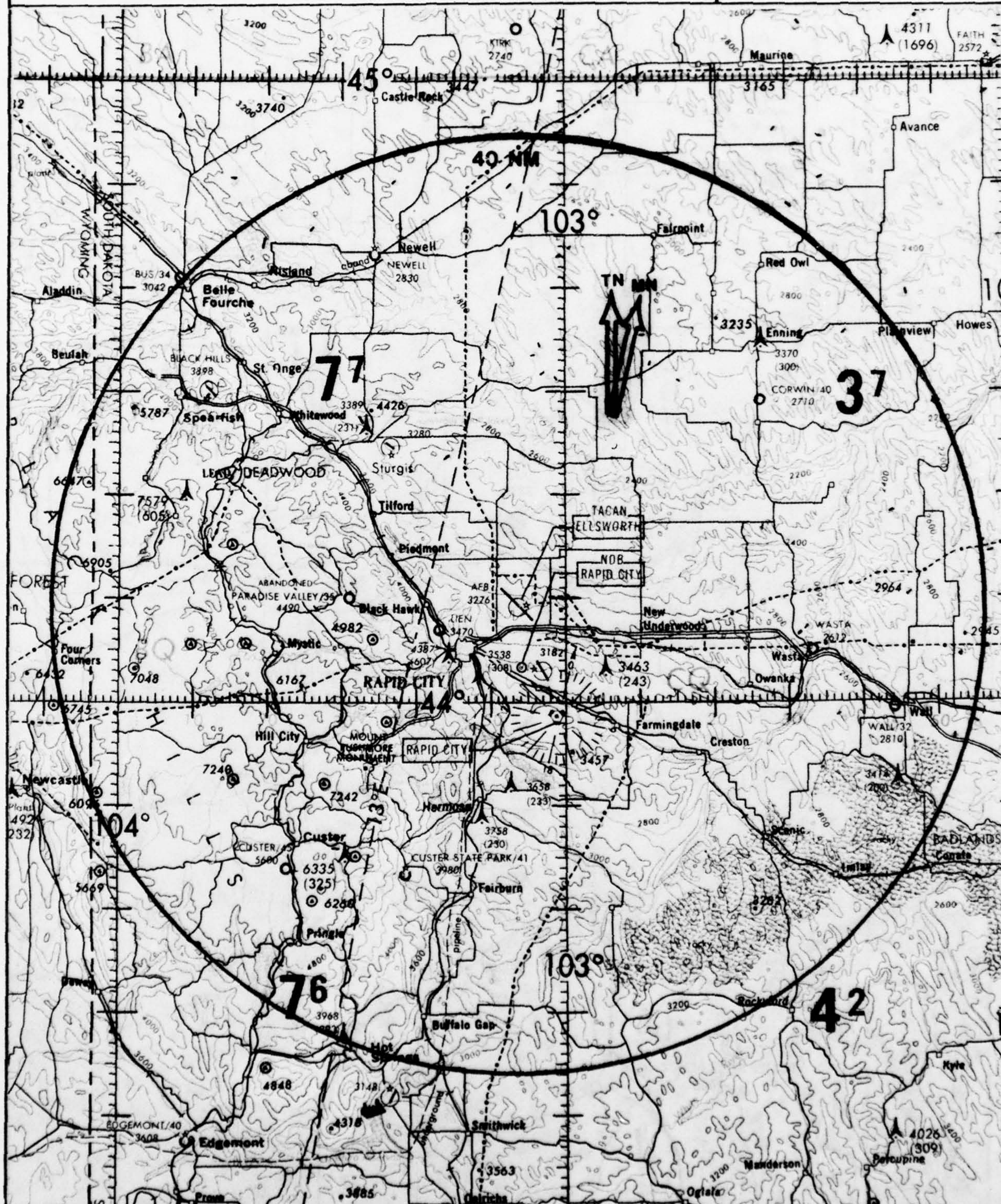
5-2. Equipment Status: The secondary power generators were in good operating condition. The automatic changeover unit at the transmitter site was awaiting parts. Manual changeover was accomplished and the generator performed satisfactorily.

5-3. Adequacy/Reliability: Primary and secondary power for all ATC communications facilities is adequate and reliable.

TITLE

GEOGRAPHICAL LOCATION AND CONTROL AREA

LOCATION	DATE
Ellsworth AFB, SD	March 1978



REMARKS

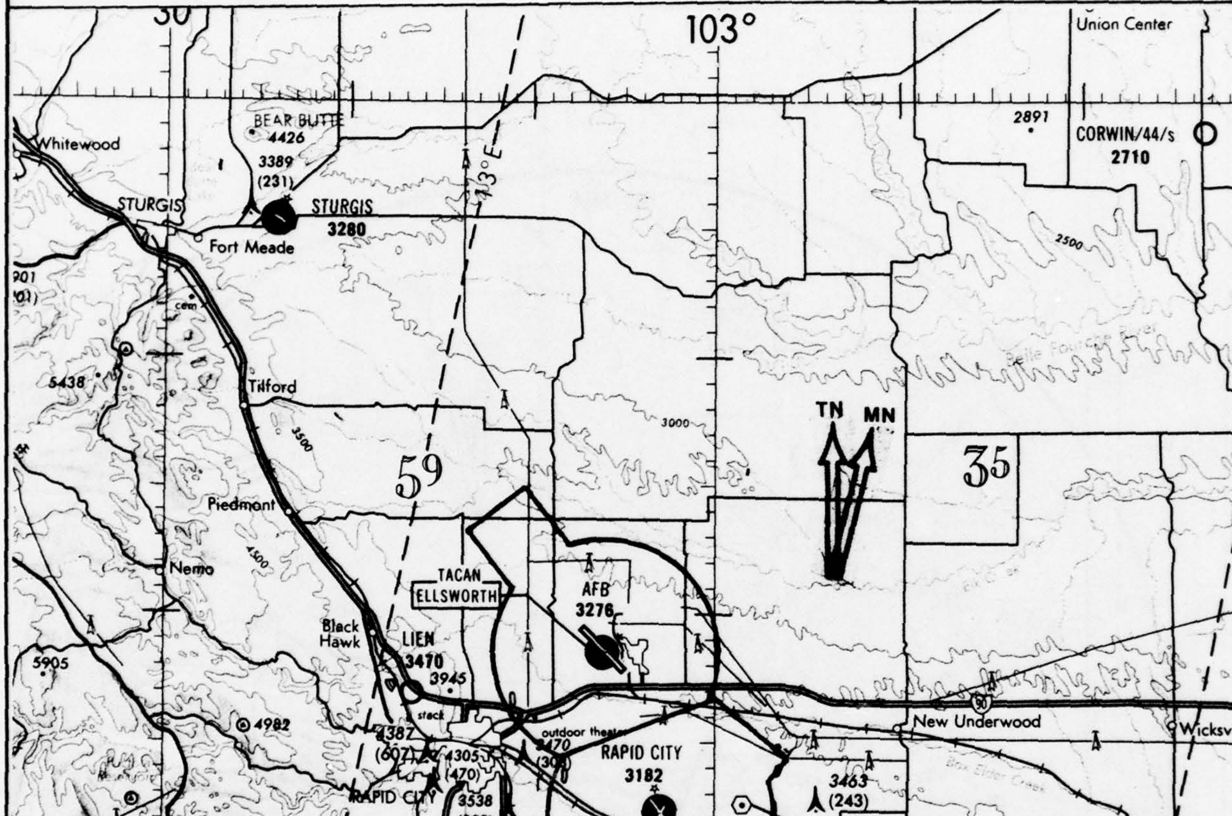
Scale: 1:1,000,000 Magnetic Declination: 13° E

TITLE:

CONTROL ZONE

LOCATION: Ellsworth AFB, SD

DATE: March 1978



REMARKS

Scale: 1:500,000 Magnetic Declination: 13° E

TITLE:

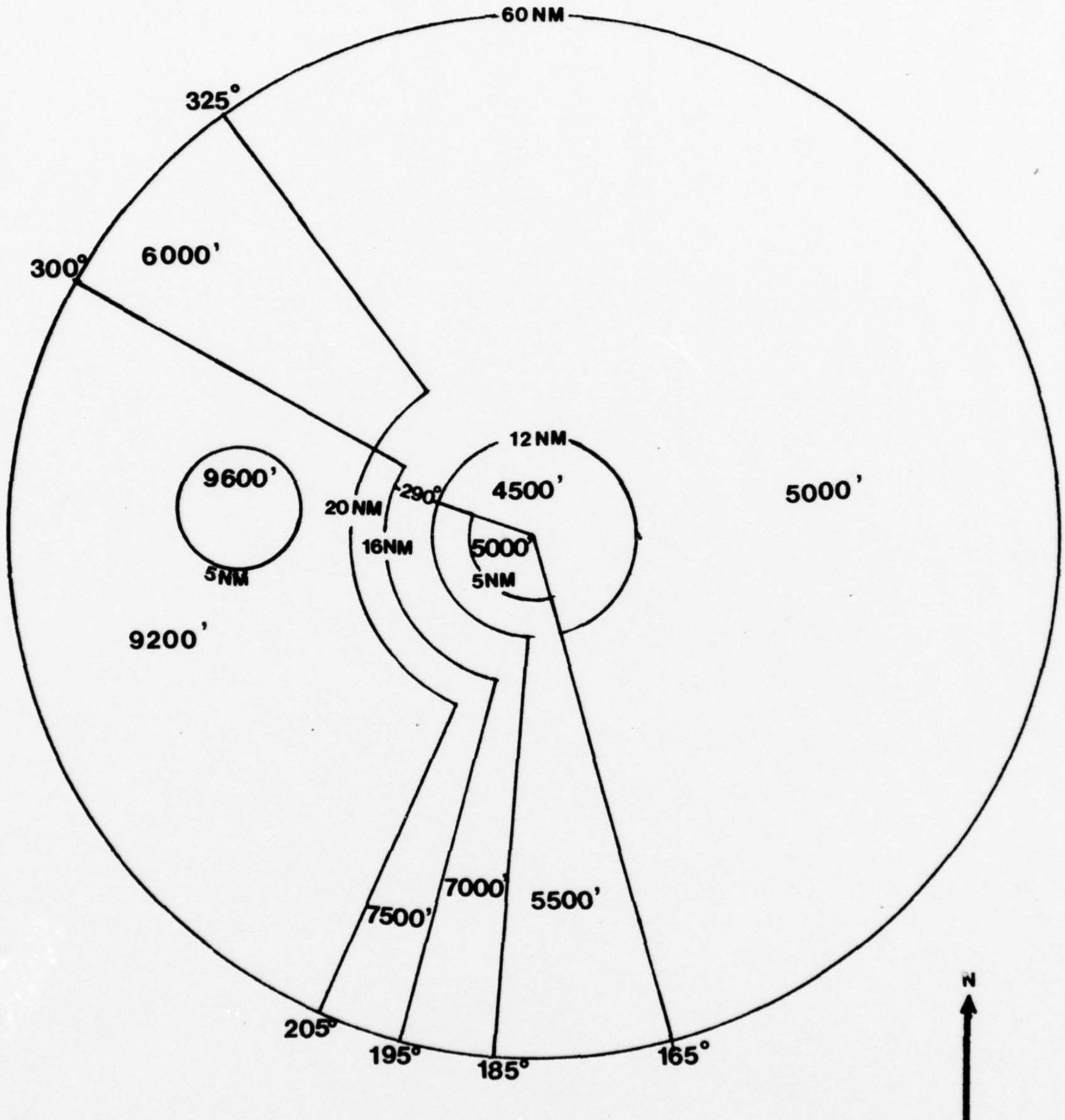
MINIMUM VECTORING ALTITUDE CHART

LOCATION

Ellsworth AFB, SD

DATE

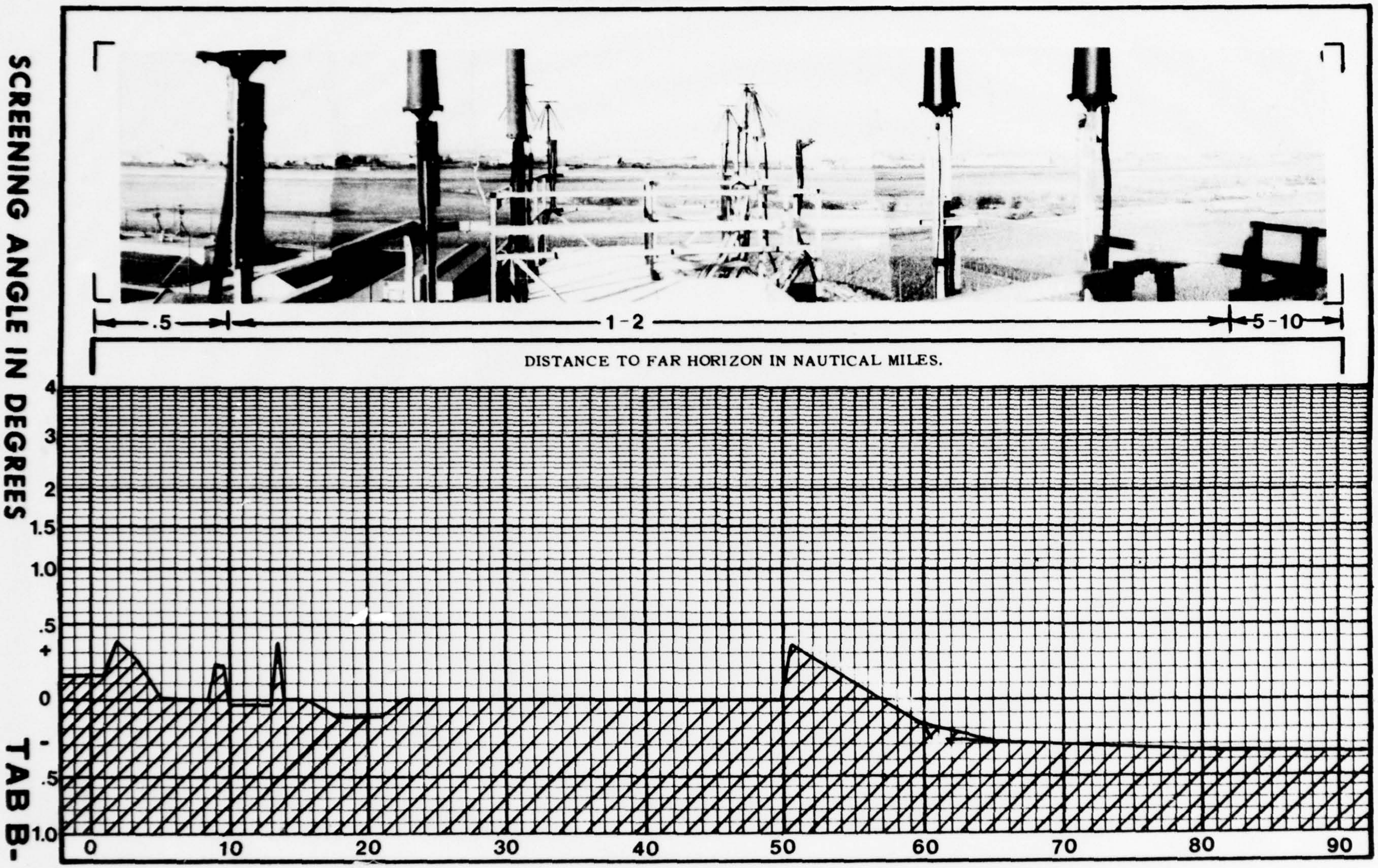
March 1978



ORIENTED TO MAGNETIC NORTH

REMARKS

SKYLINE GRAPH



ORIENTED TO: MAGNETIC NORTH

STATION ELLSWORTH AFB, SD

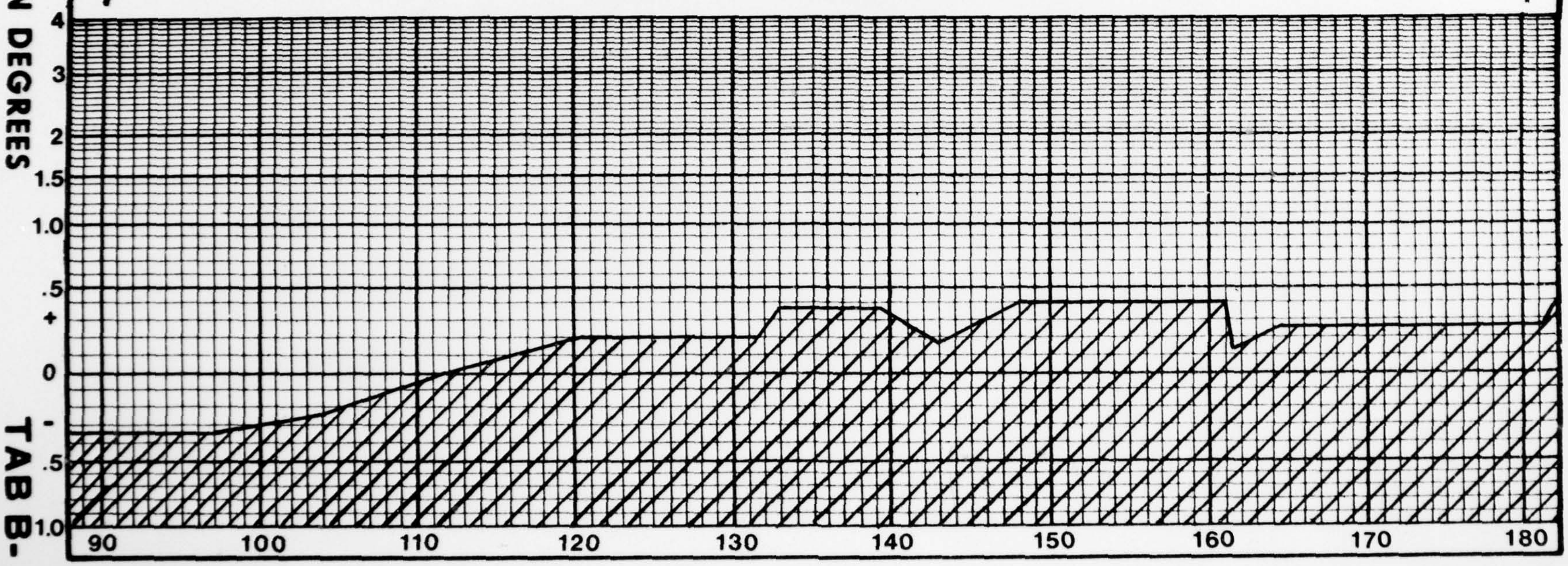
EQUIPMENT RECEIVERS

AFCS FORM MAY 73 913

SKYLINE GRAPH

5-10 | 1-3

DISTANCE TO FAR HORIZON IN NAUTICAL MILES.



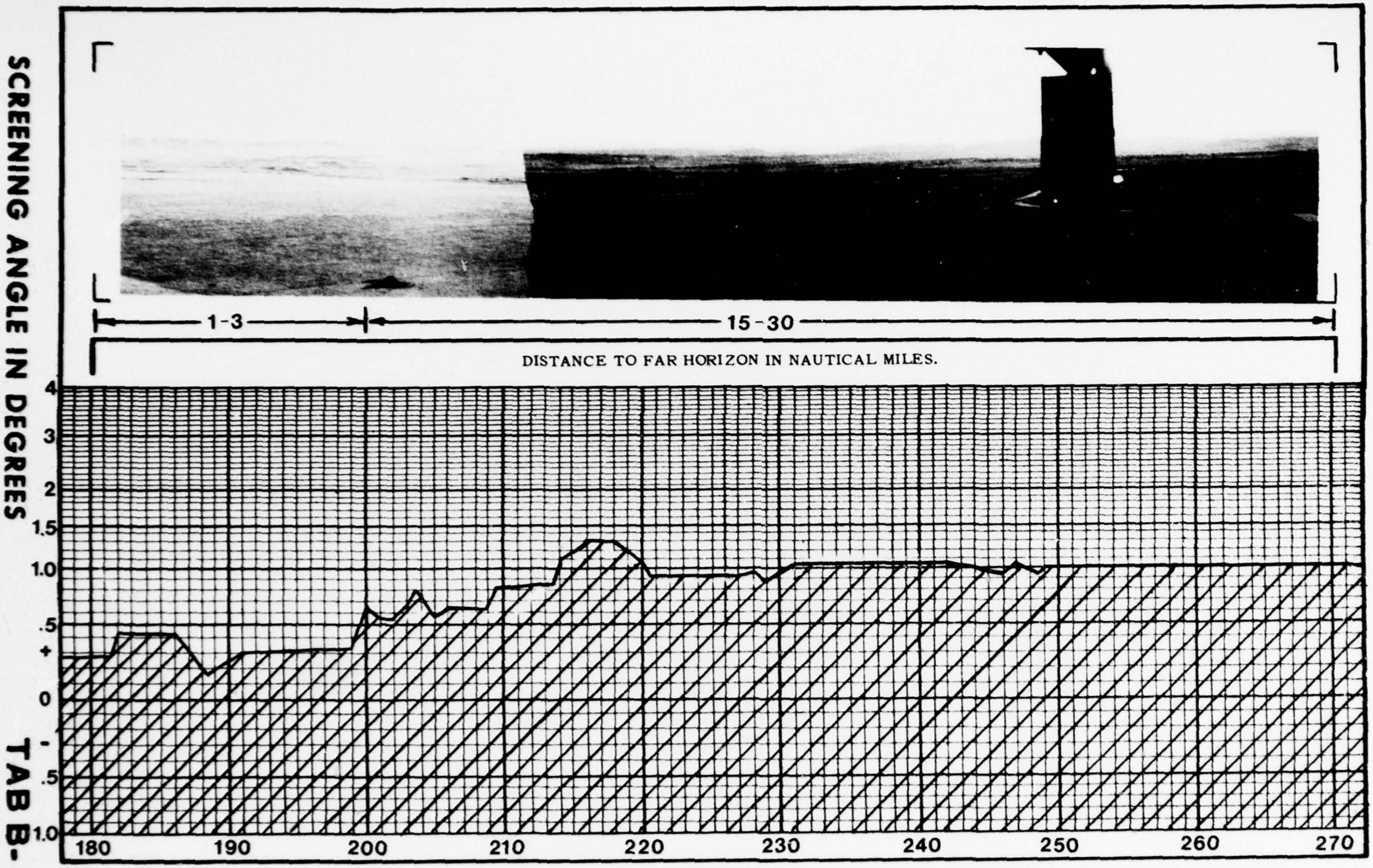
ORIENTED TO: MAGNETIC NORTH

STATION ELLSWORTH AFB, SD

EQUIPMENT RECEIVERS

AFCS FORM MAY 73 913

SKYLINE GRAPH



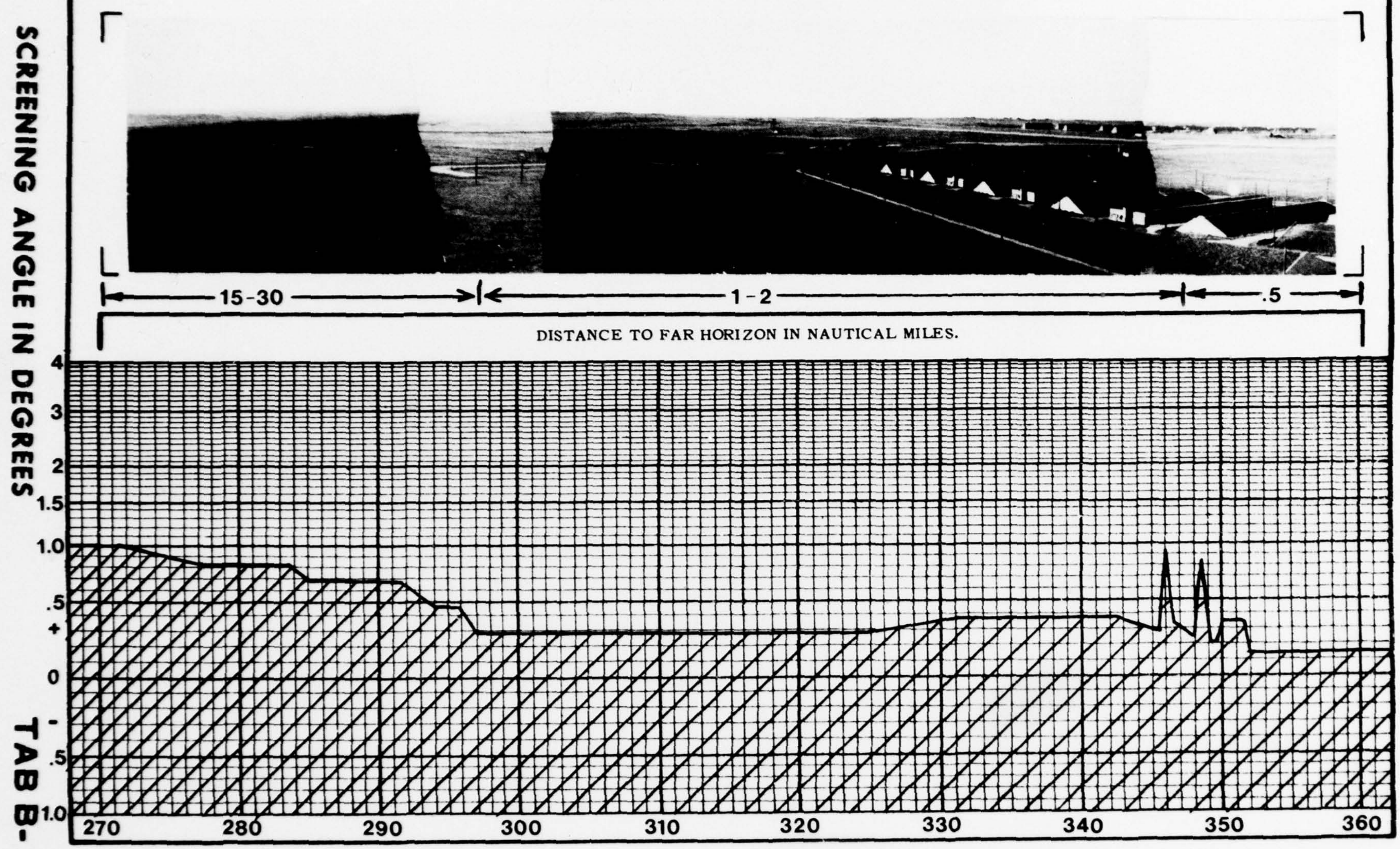
ORIENTED TO: MAGNETIC NORTH

STATION ELLSWORTH AFB, SD

EQUIPMENT RECEIVERS

AFCS FORM MAY 73 913

SKYLINE GRAPH



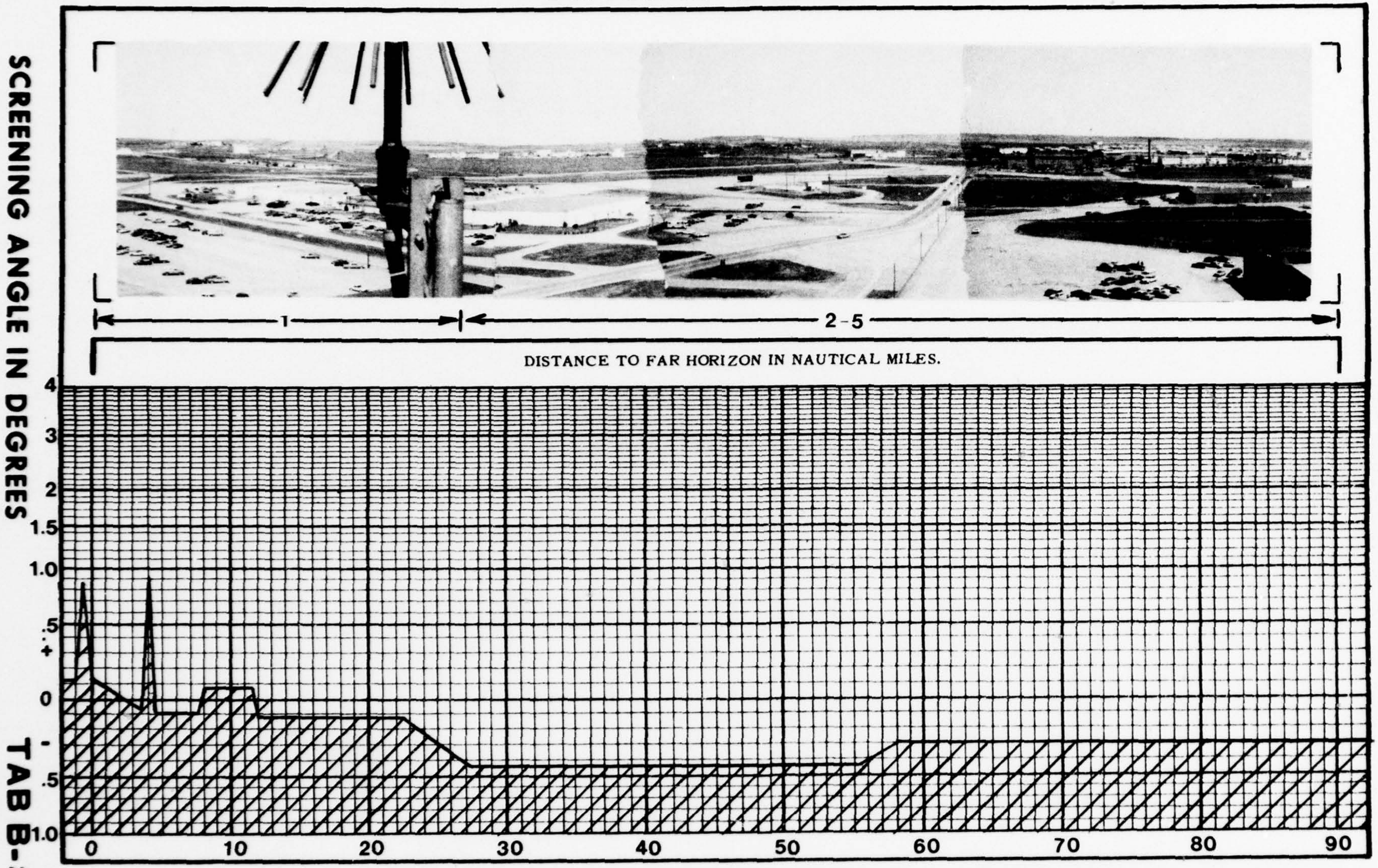
ORIENTED TO: MAGNETIC NORTH

STATION ELLSWORTH AFB, SD

EQUIPMENT RECEIVERS

AFCS FORM MAY 73 913

SKYLINE GRAPH



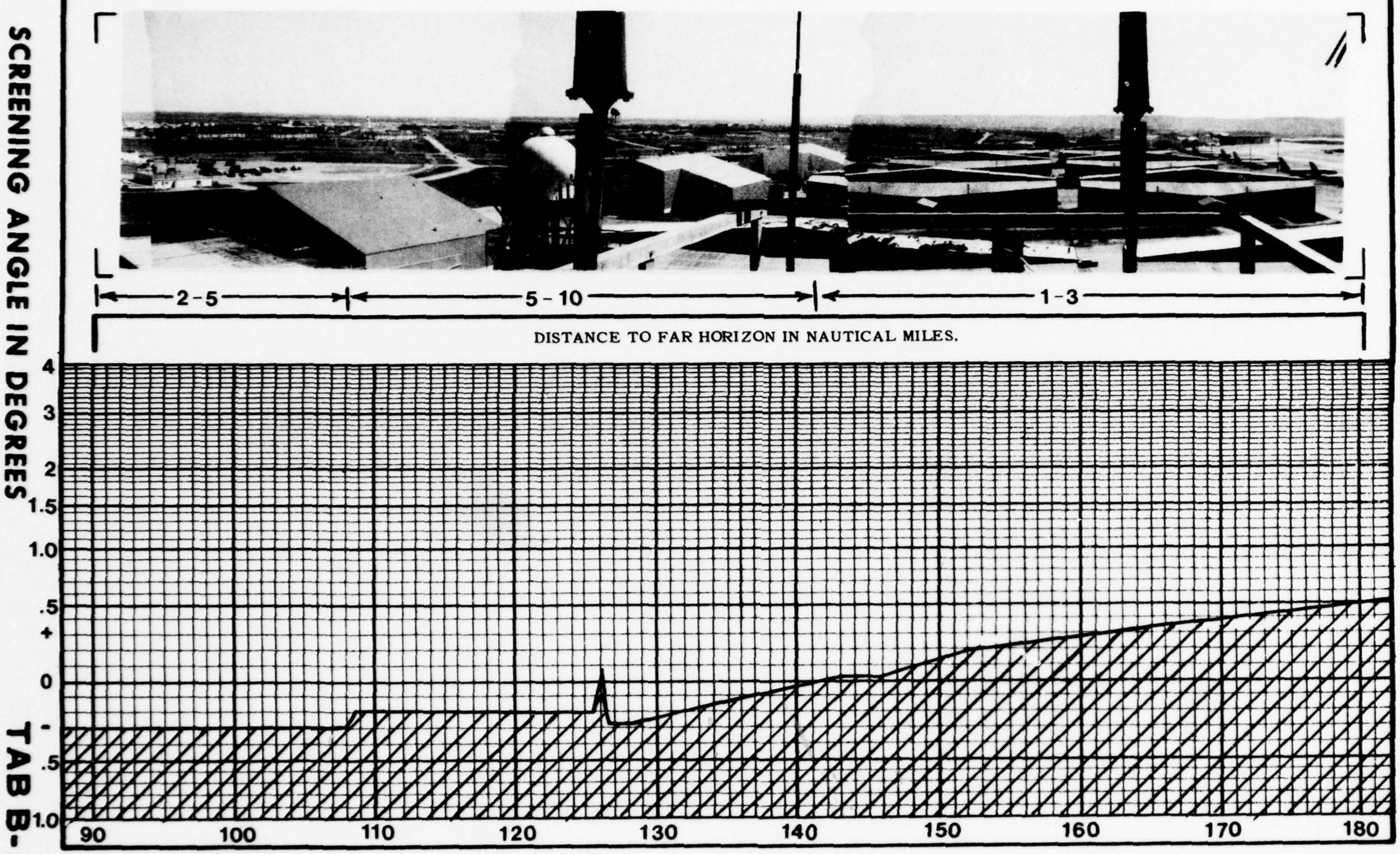
ORIENTED TO: MAGNETIC NORTH

STATION ELLSWORTH AFB, SD

EQUIPMENT RAPCON BACKUP

AFCS FORM MAY 73 913

SKYLINE GRAPH



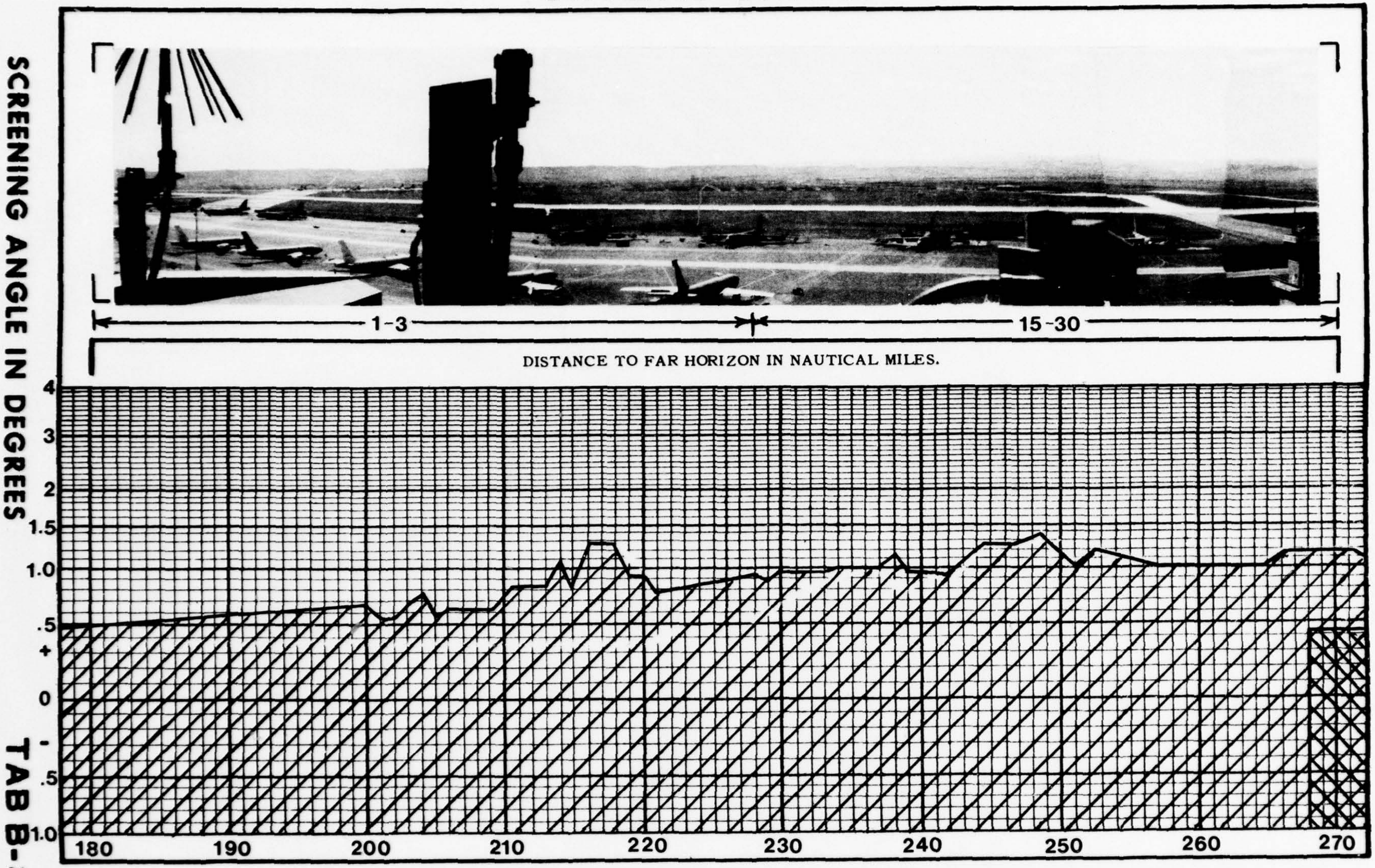
ORIENTED TO: MAGNETIC NORTH

STATION ELLSWORTH AFB, SD

EQUIPMENT RAPCON BACKUP

AFCS FORM MAY 73 913

SKYLINE GRAPH



ORIENTED TO: MAGNETIC NORTH

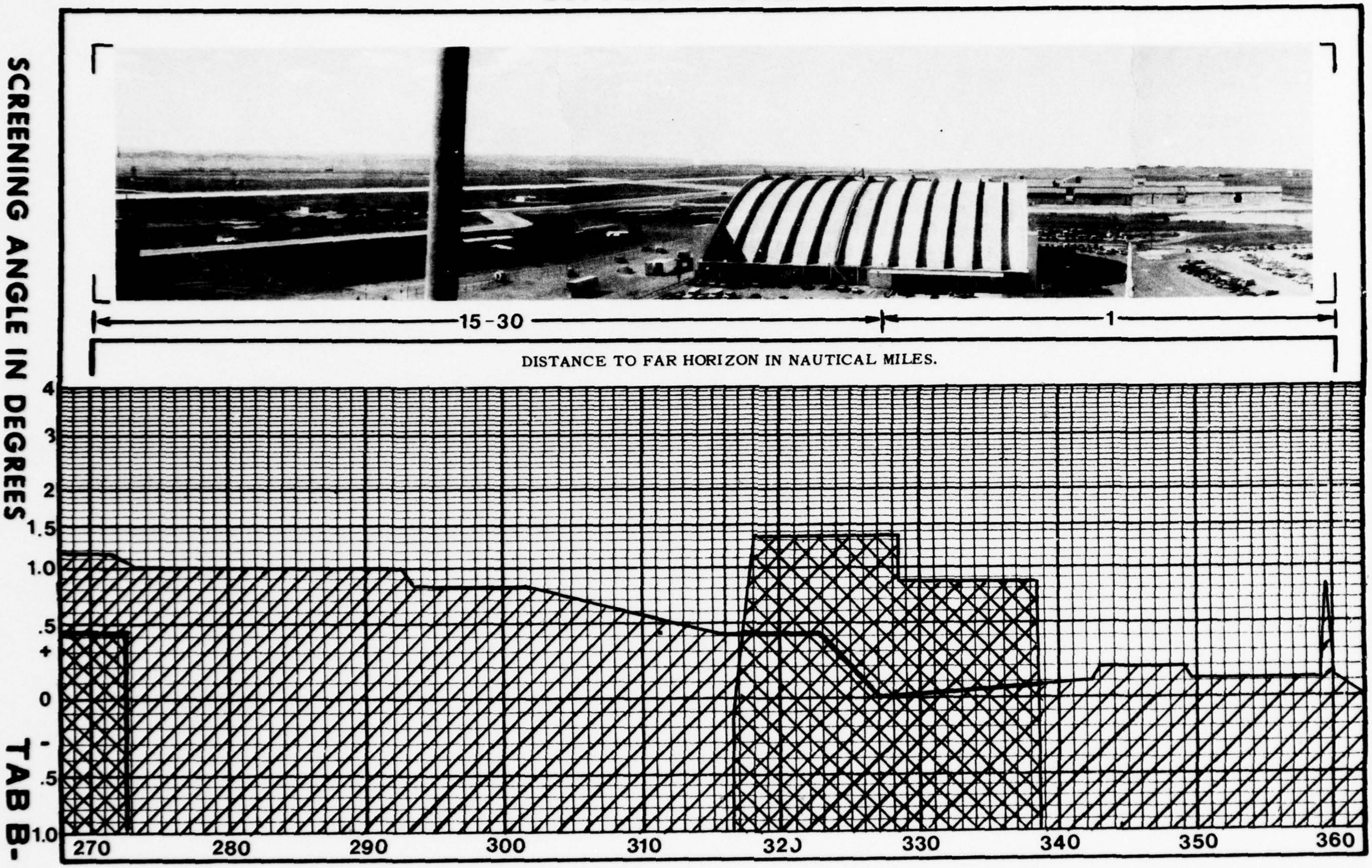
STATION ELLSWORTH AFB, SD

EQUIPMENT RAPCON BACKUP

AFCS FORM MAY 73 913

CROSSHATCHED AREA: SCREENING DUE TO 20ft. LOWERING OF TOWER

SKYLINE GRAPH



ORIENTED TO: MAGNETIC NORTH

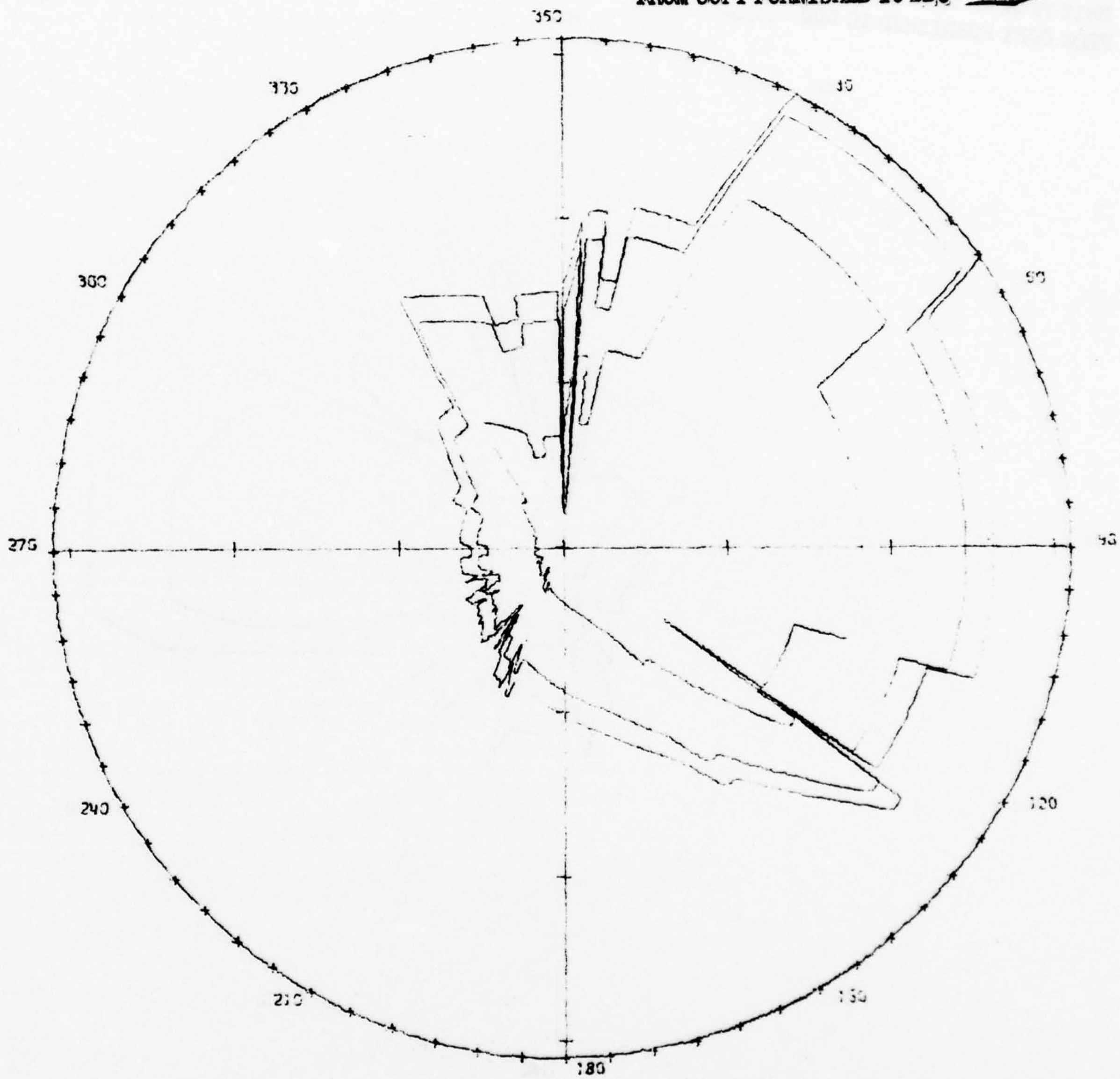
STATION ELLSWORTH AFB, SD

EQUIPMENT RAPCON BACKUP

AFCS FORM MAY 73 913

CROSSHATCHED AREA: SCREENING DUE TO 20ft. LOWERING OF TOWER

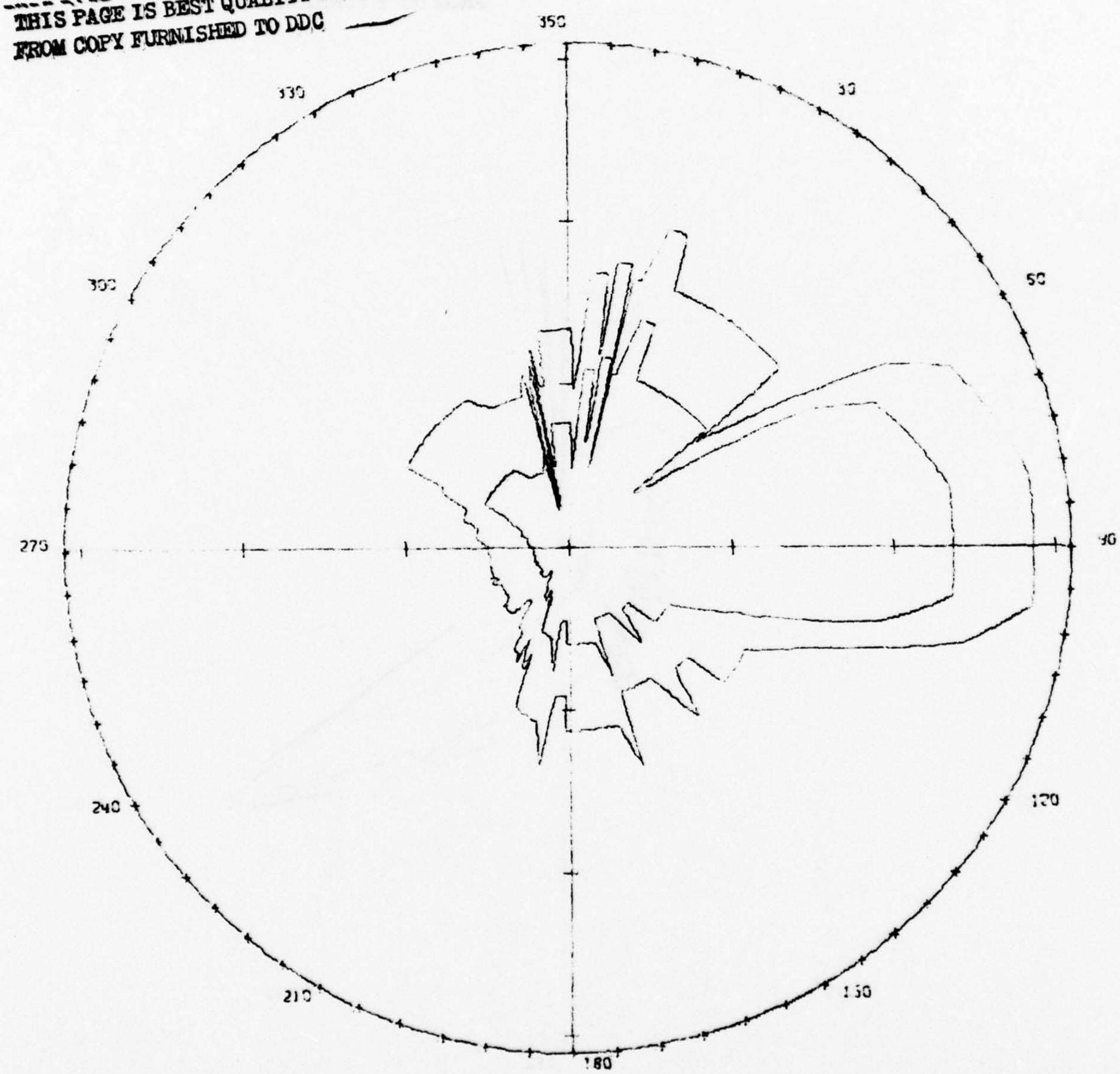
LINE OF SIGHT COVERAGE (RLS)



ELLSWORTH AFB
RAPCON
29 MAR 78
ANTENNA ELEVATION 3317 FT MSL
SCALE: 1 INCH = 35 NM
ORIENTED TO MAGNETIC NORTH

ALTITUDES FT. MSL
4000
5500
6000
VARIATION 13 DEG E

LINE OF SIGHT COVERAGE (RLS)



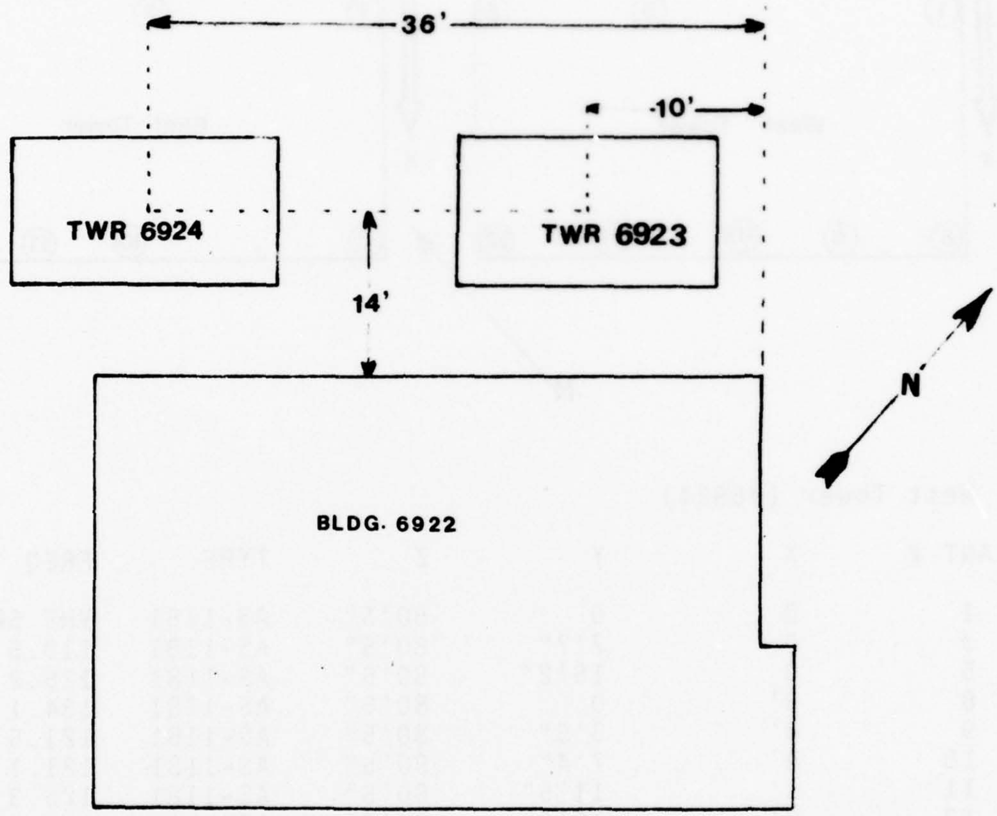
ELLSWORTH AFB
RECEIVERS
29 MAR 78
ANTENNA ELEVATION 3274 FT MSL
SCALE: 1 INCH = 30 NM
ORIENTED TO MAGNETIC NORTH

ALTITUDES FT. MSL
4000
5000
VARIATION 13 DEG E

TITLE:

RECEIVER SITE LAYOUT

LOCATION	DATE
Ellsworth AFB, SD	March 1978



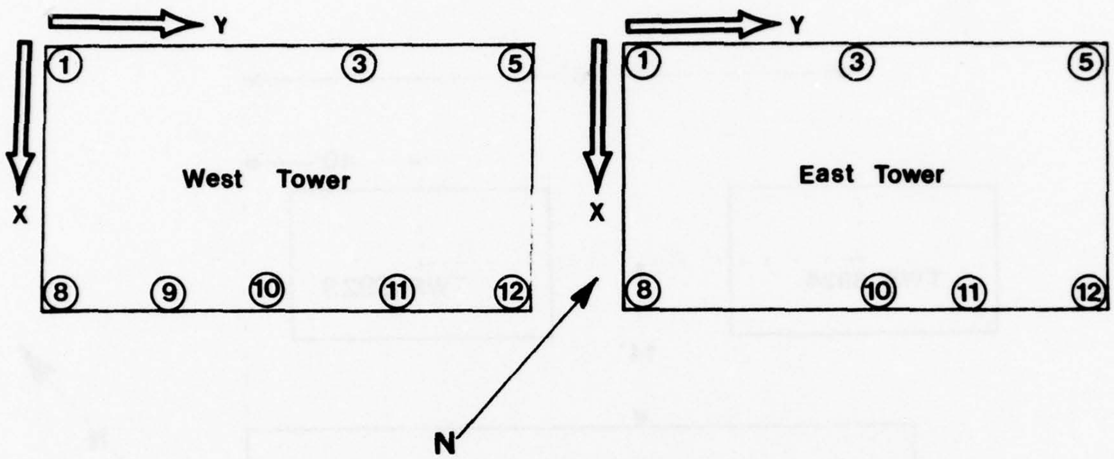
REMARKS

TITLE:

RECEIVER SITE ANTENNA LAYOUT

LOCATION: Ellsworth AFB, SD

DATE: March 1978



West Tower (#6924)

ANT #	X	Y	Z	TYPE	FREQ
1	0	0	80'5"	AS-1181	VHF SPARE
3	0	7'7"	80'5"	AS-1181	119.5
5	0	15'2"	80'5"	AS-1181	126.2
8	8'	0	80'5"	AS-1181	134.1
9	8'	3'5"	80'5"	AS-1181	121.5
10	8'	7'4"	80'5"	AS-1181	121.1
11	8'	11'5"	80'5"	AS-1181	125.3
12	8'	15'2"	80'5"	AS-1181	VHF SPARE

East Tower (#6923)

ANT #	X	Y	Z	TYPE	FREQ
1	0	0	80'5"	AS-1097	375.2
3	0	7'7"	80'5"	AT-197	271.3/390.8 396.0/289.4
5	0	15'2"	80'5"	AT-197	259.1/363.8 SPARE/275.8
8	8'	0	80'5"	AT-197	UHF SPARE
10	8'	7'4"	80'5"	AT-197	236.6/243.0 253.5/284.0
11	8'	11'5"	80'5"	AT-197	UHF SPARE
12	8'	15'2"	80'5"	AT-197	372.2

REMARKS

X, Y, and Z indicates three dimensional coordinates

TITLE

EQUIPMENT ANALYSIS SPECIFICATION LIST

FREQUENCY: Self Explanatory

1. Equipment Type: Transmitters AN/GRT-21 and AN/GRT-22 (TO 31R2-2GRT-102)

2.	Transmitter Serial Number:----------:	Obtained from equipment
3.	Percent of Modulation, 0 dBm Input:-:	90%±10%
4.	Percent of Modulation, -15 dBm Input:	90%±10%
5.	Percent of Modulation, +10 dBm Input:	90%±10%
6.	Distortion:------------------------:	10% at lower limiting 15% at upper limiting
7.	Frequency Accuracy Tolerance:-------:	±0.001% with CR-143 crystal ±0.002% with CR-75 crystal ±0.0005% with freq synthesizer
8.	Power Output:----------------------:	10 Watts Minimum, Low power mode 50 Watts Minimum, High power mode
9.	Reflected Power:-------------------:	2.5 Watts max, 10 Watts forward 12.5 Watts max, 50 Watts forward
10.	Transmission System VSWR:-----------:	Normal operation at carrier power with VSWR not greater than 3 to 1
11.	Coupler Loss:----------------------:	2 dB Maximum (TO 31R1-2GR-142) CU-547
12.	Antenna VSWR:----------------------:	2:1 Maximum (TO 31R1-2GR-241) AS-1097 1.6:1 Maximum (TO 31R1-2GR-161) AT-197

13. Receiver Nomenclature: Receivers AN/GRR-23 and AN/GRR-24 (TO 31R2-2GRR-112)

14.	Receiver Serial Number:-------------:	Obtained from equipment
15.	Frequency Accuracy Tolerance:-------:	±0.001% with CR-143 crystal ±0.002% with CR-75 crystal ±0.0005% with freq synthesizer
16.	Sensitivity:-----------------------:	3 uv Maximum
17.	Signal to Noise:-------------------:	10 dB with a 3 uv input
18.	Squelch Threshold:-----------------:	3 uv (TO 31R2-2GRR-116WC-1, 28 day inspection)
19.	AGC Characteristics:_______________:	3 dB Maximum variation with input signal of 6 uv to 1 v
20.	Audio Output:----------------------:	+20 dBm
21.	Distortion:------------------------:	For frequencies 300, 1,500, and 3000 Hz with a 1 v input 10% maximum with 30% modulation 20% maximum with 90% modulation
22.	Transmission System VSWR:-----------:	NSA (No Specifications Available)
23.	Antenna VSWR:----------------------:	2:1 Maximum (TO 31R1-2GR-241) AS-1097 1.6:1 Maximum (TO 31R1-2GR-161) AT-197
24.	Coupler Loss:----------------------:	2 dB Maximum (TO 31R1-2GR-142) CU-547

REMARKS

TITLE

EQUIPMENT ANALYSIS SPECIFICATION LIST

FREQUENCY: Self Explanatory

1. Equipment Type: Transmitter AN/GRT-18 (TO 31R2-GRT18-2)

2. Transmitter Serial Number:------------: Obtained from equipment
3. Percent of Modulation, 0 dBm Input:---: 90% Minimum
4. Percent of Modulation, -15 dBm Input:-: 90% Minimum
5. Percent of Modulation, +10 dBm Input:-: 90% Minimum (50 Watt mode only).
6. Distortion:---------------------------: NSA (No specification available).
7. Frequency Accuracy Tolerance:---------: ±0.0014% of the assigned frequency.
8. Power Output:-------------------------: 10 Watts Minimum, Low power mode
   50 Watts Minimum, High power mode.
9. Reflected Power:----------------------: 1.1 Maximum, 10 Watts forward
   5.5 Maximum, 50 Watts forward
10. Transmission System VSWR:-------------: 2:1 Maximum
11. Coupler Loss:-------------------------: NA
12. Antenna VSWR:-------------------------: 2:1 Maximum (TO 31R1-2UR-31) AS-1181

13. Receiver Nomenclature: Receiver AN/GRR-25 (TO 31R2-2GRR25-2)

14. Receiver Serial Number:---------------: Obtained from equipment
15. Frequency Accuracy Tolerance:---------: ±0.002%
16. Sensitivity:--------------------------: 5 uv
17. Signal to Noise:----------------------: 10 dB with 5 uv input
18. Squelch Threshold:--------------------: 3 uv maximum at max rf gain
19. AGC Control:--------------------------: 3 dB maximum variation with input signals of 15 uv to 1 v
20. Audio Output:-------------------------: +10 to +30 dBm main audio (-10 to +10 dBm low level)
21. Distortion:---------------------------: 15% Maximum with a 1 v rf input signal modulated at 30%
   25% Maximum with a 1 v rf input signal modulated at 90%
22. Transmission System VSWR:-------------: NSA
23. Antenna VSWR:-------------------------: 2:1 Maximum (TO 31R1-2UR-31) AS-1181
24. Coupler Loss:-------------------------: NA

REMARKS

AM RADIO COMMUNICATIONS EQUIPMENT ANALYSIS					DATE March 1978	
LOCATION Ellsworth AFB, SD						
FREQUENCY	390.8		363.8		236.6	
1. TRANSMITTER NOMENCLATURE	AN/GRT-22		AN/GRT-22		AN/GRT-22	
2. SERIAL NUMBER	6652		7082		6646	
	INITIAL	ADJUSTED	INITIAL	ADJUSTED	INITIAL	ADJUSTED
3. MODULATION LEVEL %	90		90		+100	90
4. LOWER LIMITING %	90		90		90	
5. UPPER LIMITING %	90		90		90	
6. DISTORTION %	2.2		3.8		22	6
7. FREQUENCY ACCURACY %	0.00		0.00		0.00	
8. RF POWER OUT FORWARD Watts	14	10	14	10	14	10
9. COUPLER VSWR	N/A		N/A		1.1:1	
10. COUPLER LOSS dB	N/A		N/A		2.6	
11. ANTENNA VSWR	1.1:1		1.1:1		1.2:1	
12. RECEIVER NOMENCLATURE	AN/GRR-24		AN/GRR-24		AN/GRR-24	
13. SERIAL NUMBER	6402		6310		3051	
14. FREQUENCY ACCURACY %	0.00		0.00		0.00	
15. SENSITIVITY UV	1.7		3.4	1.5	9.1	
16. SIGNAL TO NOISE dB	14.1		9.1	15.1	2.0	
17. SQUELCH THRESHOLD UV	3.0		2.4	3.0	* NOTE	
18. AGC	1.6		1.2			
19. AUDIO OUT dBm	20		16	20		
20. DISTORTION %	4.6		5.6			
21. COUPLER VSWR	1.3:1		1.1:1			
22. COUPLER LOSS dB	1.6		1.4			
23. ANTENNA VSWR	1.5:1		1.1:1			

REMARKS
* Check was terminated when receiver would not adjust to specifications.

AM RADIO COMMUNICATIONS EQUIPMENT ANALYSIS					DATE March 1978	
LOCATION Ellsworth AFB, SD						
FREQUENCY	125.3		121.5			
1. TRANSMITTER NOMENCLATURE	AN/GRT-21		AN/GRT-21			
2. SERIAL NUMBER	10174		10914			
	INITIAL	ADJUSTED	INITIAL	ADJUSTED	INITIAL	ADJUSTED
3. MODULATION LEVEL %	90		+100	90		
4. LOWER LIMITING %	90		90			
5. UPPER LIMITING %	90		90			
6. DISTORTION %	5.4		4.8			
7. FREQUENCY ACCURACY %	0.00		0.00			
8. RF POWER OUT FORWARD Watts	10		53	50		
9. COUPLER VSWR	N/A		N/A			
10. COUPLER LOSS dB	N/A		N/A			
11. ANTENNA VSWR	1.2:1		1.4:1			
12. RECEIVER NOMENCLATURE	AN/GRR-25		AN/GRR-25			
13. SERIAL NUMBER	822		836			
14. FREQUENCY ACCURACY %	+.00016		+.0004			
15. SENSITIVITY UV	3	1.8	1.5			
16. SIGNAL TO NOISE dB	10	20	15			
17. SQUELCH THRESHOLD UV	3.3	3	3			
18. AGC	2.6	1.8	1.1			
19. AUDIO OUT dBm	-1	* 0	* 0			
20. DISTORTION %	20	17	5.1			
21. COUPLER VSWR	N/A		N/A			
22. COUPLER LOSS dB	N/A		N/A			
23. ANTENNA VSWR	1.4:1		1.6:1			

REMARKS

* Measurement taken at the output of Altec amplifiers.

TITLE

AMPLIFIER DATA

LOCATION: RAPCON

DATE: March 1978

Type AM-4568/G Microphone Amplifier

Serial Number						
Position	PAR-1	PAR-2	ASR-1	ASR-2	ASR-3	CORD
Input Level (dBm)	-10	-10	-10	-10	-10	-10
Output Level (VRMS)	6.1	4.4	6.3	6.4	6.4	4.6
% Distortion (5% Max)	2.9	2.4	2.5	2.5	2.8	6.4
Noise Level (dBm)	-57	-66	-62	-66	-66	-66
Input at Limiting (dBm)	-13	-13	-13	-13	-13	-13
Output at Limiting (dBm)	*	*	*	*	*	*

* NOTE: Unable to measure with available test equipment because of the higher than normal input level.

Type AM-4568/G Microphone Amplifier

Serial Number						
Position	CL/DL	MAINT				
Input Level (dBm)	-10	-10				
Output Level (VRMS)	6.8	6.2				
% Distortion (5% Max)	2.3	2.1				
Noise Level (dBm)	-62	-63				
Input at Limiting (dBm)	-13	-13				
Output at Limiting (dBm)	*	*				

* NOTE: Unable to measure with available test equipment because of the higher than normal input level.

REMARKS

TITLE

AMPLIFIER DATA

LOCATION: RAPCON

DATE: March 1978

Type AM-4571/G Line Amplifier

Frequency		298.4	125.3	259.1	243.0	121.5	121.5
Input Level	(dBm)	-5.8	-5	-5	-5	-5	-5
Output Level	(dBm)	28	28	27	28	28	28
% Distortion	(5% Max)	4	2.75	3.6	2.05	3.5	2.9
Noise Level	(dBm)	-46	-45	-47	-46	-46	-46

Type AM-4571/G Line Amplifier

Frequency		384.0	363.8	396.0	390.8	119.5	271.3
Input Level	(dBm)	-5	-5	-5	-5	-5	-5
Output Level	(dBm)	28	27.5	28	28	27.5	27.6
% Distortion	(5% Max)	2.5	2.9	2.6	2.8	3.5	3.7
Noise Level	(dBm)	-46	-45	-42	-44	-45	-46

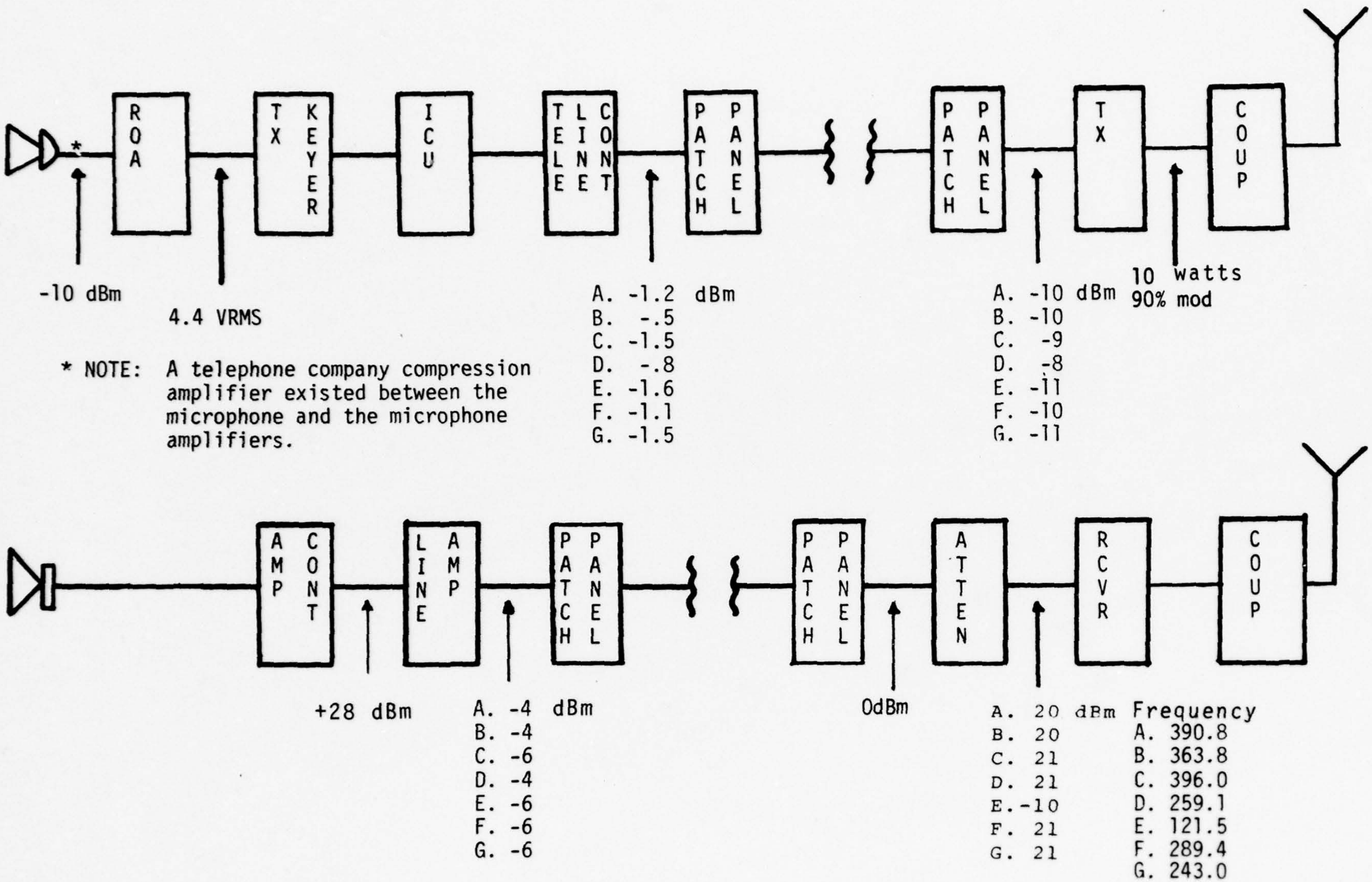
Type AM-4571/G Line Amplifier

Frequency		134.1	UHF MULTI CH	VHF MULTI CH	VHF SPARE	UHF SPARE	
Input Level	(dBm)	-5	-1	-1	-1	-1	
Output Level	(dBm)	28	28	28	28	28	
% Distortion	(5% Max)	3.1	3	3.8	3.5	3.2	
Noise Level	(dBm)	-41.5	-46.6	-45.6	-44	-45.2	

REMARKS

AM RADIO COMMUNICATIONS SYSTEM LOOP ANALYSIS					DATE March 1978		
LOCATION: RAPCON							
1. FREQUENCY:	390.8	363.8	396.0	259.1	121.5	289.4	243.0
2. MIC AMP IN dBm	-10	-10	-10	-10	-10	-10	-10
3. MIC AMP OUT VRMS	4.4	4.4	4.4	4.4	4.4	4.4	4.4
4. NOISE FLOOR dB Down	32	32	32	32	32	32	32
5. NOISE LEVEL dBm	-66	-66	-66	-66	-66	-66	-66
6. CABLE IN dBm	-1.2	-.5	-1.5	-.8	-1.6	-1.1	-1.5
7. NOISE FLOOR dB Down	21	32	31	32	19	32	31
8. NOISE LEVEL dBm	-30	-30	-30	-30	-28	-30	-28
9. CABLE OUT dBm	-10	-10	-9	-8	-11	-10	-11
10. NOISE FLOOR dB Down	37	37	38	38	37	37	37
11. NOISE LEVEL dBm	-56	-65	-61	-59	-66	-64	-67
12. TRANSMITTER IN dBm	-10	-10	-9	-8	-11	-10	-11
13. % MODULATION %	90	90	90	90	90	90	90
14. POWER OUT Watts	10	10	10	10	10	10	10
15. RECEIVER OUT dBm	20	20	21	21	* 0	21	21
16. NOISE FLOOR dB Down	31	28	30	29	22	28	29
17. NOISE LEVEL dBm	-23	-27	-24	-24	-6	-25	-24
18. CABLE IN dBm	0	0	0	0	0	0	0
19. NOISE FLOOR dB Down	32	30	31	30	24	30	30
20. NOISE LEVEL dBm	-27	-30	-30	-28	-12	-30	-29
21. CABLE OUT dBm	-4	-4	-6	-4	-6	-6	-6
22. NOISE FLOOR dB Down	34	32	31	30	24	30	30
23. NOISE LEVEL dBm	-31	-35	-36	-32	-19	-36	-35

* Measurement taken at output of ALTEC amps.



* NOTE: A telephone company compression amplifier existed between the microphone and the microphone amplifiers.

LOOP TEST LINE LEVEL DIAGRAM
(RAPCON)

TITLE

AMPLIFIER DATA

LOCATION: Control Tower

DATE: March 1978

Type AM-4571/G Line Amplifier

Frequency	236.6	126.2	253.5	396.0	243.0	289.4
Input Level (dBm)	-4	-3	-3	-7	-7	-7
Output Level (dBm)	26	26	26	26	26	26
% Distortion (5% Max)	2.6	3.5	1.5	4.4	1.5	3.5
Noise Level (dBm)	-30	-55	-57.5	-59	-54.5	-56

Type AM-4571/G Line Amplifier

Frequency	121.5	275.8				
Input Level (dBm)	-7	-3				
Output Level (dBm)	26	26				
% Distortion (5% Max)	1.75	1.95				
Noise Level (dBm)	-56	-57				

Type AM-4571/G

Input Level (dBm)						
Output Level (dBm)						
% Distortion (5% Max)						
Noise Level (dBm)						

REMARKS

TITLE

AMPLIFIER DATA

LOCATION	DATE
Control Tower	March 1978

Type AM-4571/G Speaker Amplifier

Position	POS-1 SPK-1	POS-1 SPK-2	POS-1 SPK-3	POS-2 SPK-1	POS-2 SPK-2	POS-2 SPK-3
Input Level (dBm)	-43	-39	-28	-41	-46	-47
Output Level (dBm)	8	13.5	11	9.8	12	3.5
% Distortion (5% Max)	3.6	6.9	1.4	8.2	3	2.7
Noise Level (dBm)	-55	-27	-60	-59	-57	-59

Type AM-4571/G Line Amplifier

Position	POS-3					
Input Level (dBm)	-42					
Output Level (dBm)	12					
% Distortion (5% Max)	5.2					
Noise Level (dBm)	-36					

Type AM-4571/G

Input Level (dBm)						
Output Level (dBm)						
% Distortion (5% Max)						
Noise Level (dBm)						

REMARKS

TITLE

AMPLIFIER DATA

LOCATION	DATE
Control Tower	March 1978

Type AM-4568/G Microphone Amplifier (Initial)

Serial Number	613	631	437	607		
Position	3	2	1	MAINT		
Input Level (dBm)	-30	-30	-30	-30		
Output Level (VRMS)	1.1	2.8	3.2	1.7		
% Distortion (5% Max)	1.4	1.3	1.6	1.1		
Noise Level (dBm)	-47	-65	-28	-41		
Input at Limiting (dBm)	-57	-41	-54	-59		
Output at Limiting (dBm)	-21	-5	-15	-20		

Type AM-4568/G Microphone Amplifier (Adjusted)

Serial Number	613	631	437	607		
Position	3	2	1	MAINT		
Input Level (dBm)	-30	-30	-30	-30		
Output Level (VRMS)	1.4	1.6	2.3	1.6		
% Distortion (5% Max)	0.8	1	0.8	0.9		
Noise Level (dBm)	-66	-65	-65	-65		
Input at Limiting (dBm)	-32	-33	-31	-34		
Output at Limiting (dBm)	6	0.5	5	4.5		

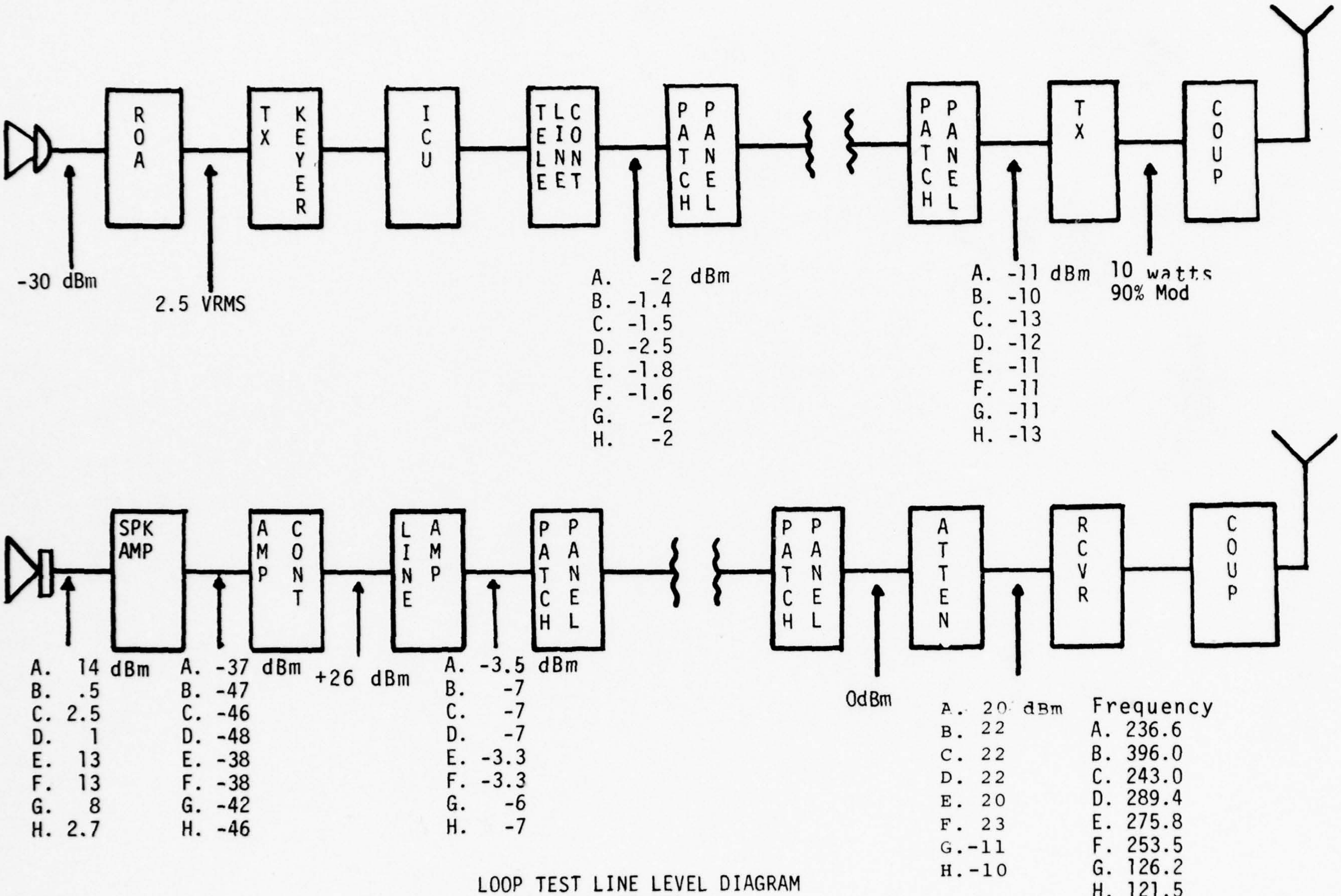
REMARKS

AM RADIO COMMUNICATIONS SYSTEM LOOP ANALYSIS					DATE March 1978			
LOCATION: Control Tower								
1. FREQUENCY:		236.6	396.0	243.0	289.4	275.8	253.5	126.2
2. MIC AMP IN	dBm	-30	-30	-30	-30	-30	-30	-30
3. MIC AMP OUT	VRMS	2.5	2.5	2.5	2.5	2.5	2.5	2.5
4. NOISE FLOOR	dB Down	31	31	31	31	31	31	31
5. NOISE LEVEL	dBm	-78	-78	-78	-78	-78	-78	-78
6. CABLE IN	dBm	-2	-1.4	-1.5	-2.5	-1.8	-1.6	-2
7. NOISE FLOOR	dB Down	35	33.6	34	33.5	33.7	33.8	34
8. NOISE LEVEL	dBm	-39	-40	-40	-39	-39	-40	-40
9. CABLE OUT	dBm	-11	-10	-13	-12	-11	-11	-11
10. NOISE FLOOR	dB Down	34	35	34	33	35	34	34
11. NOISE LEVEL	dBm	-67	-55	-56	-54	-64	-67	-67
12. TRANSMITTER IN	dBm	-11	-10	-13	-12	-11	-11	-11
13. % MODULATION	%	90	90	90	90	90	90	90
14. POWER OUT	Watts	10	10	10	10	10	10	10
15. RECEIVER OUT	dBm	20	22	22	22	20	23	* 0
16. NOISE FLOOR	dB Down	22	23	21	18	25	15	23
17. NOISE LEVEL	dBm	-34	-33	-23	-23	-30	-24	-9
18. CABLE IN	dBm	0	0	0	0	0	0	0
19. NOISE FLOOR	dB Down	35	35	30	30	28	23	20
20. NOISE LEVEL	dBm	-38	-40	-30	-30	-33	-31	-12
21. CABLE OUT	dBm	-3.5	-7	-7	-7	-3.3	-3.3	-6
22. NOISE FLOOR	dB Down	38	35	30	30	30	25	23
23. NOISE LEVEL	dBm	-40	-48	-37	-37	-35	-34	-15
24. SPEAKER AMP IN	dBm	-37	-47	-46	-48	-38	-38	-42
25. SPEAKER AMP OUT	dBm	14	.5	2.5	1	13	13	8
26. NOISE FLOOR	dB Down	19	28.5	25	27	17	17	15
27. NOISE LEVEL	dBm	-34	-37	-28	-30	-14	-28	-0.5

* Measurements taken at output of ALTEC amp.

AM RADIO COMMUNICATIONS SYSTEM LOOP ANALYSIS									DATE March 1978
LOCATION: Control Tower									
1. FREQUENCY:		121.5							
2. MIC AMP IN	dBm	-30							
3. MIC AMP OUT	VRMS	2.5							
4. NOISE FLOOR	dB Down	31							
5. NOISE LEVEL	dBm	-78							
6. CABLE IN	dBm	-2							
7. NOISE FLOOR	dB Down	34							
8. NOISE LEVEL	dBm	-40							
9. CABLE OUT	dBm	-13							
10. NOISE FLOOR	dB Down	33							
11. NOISE LEVEL	dBm	-55							
12. TRANSMITTER IN	dBm	-13							
13. % MODULATION	%	90							
14. POWER OUT	Watts	10							
15. RECEIVER OUT	dBm	* 0							
16. NOISE FLOOR	dB Down	21							
17. NOISE LEVEL	dBm	-8							
18. CABLE IN	dBm	0							
19. NOISE FLOOR	dB Down	25							
20. NOISE LEVEL	dBm	-12							
21. CABLE OUT	dBm	-7							
22. NOISE FLOOR	dB Down	24							
23. NOISE LEVEL	dBm	-20							
24. SPEAKER AMP IN	dBm	-46							
25. SPEAKER AMP OUT	dBm	2.7							
26. NOISE FLOOR	dB Down	25							
27. NOISE LEVEL	dBm	-9							

* Measurement taken at output of ALTEC amp.



LOOP TEST LINE LEVEL DIAGRAM
(CONTROL TOWER)

A. C. POWER							DATE March 1978

LOCATION: Control Tower

EQUIPMENT & SERIAL NUMBER:

CHECK	SPECIFICATIONS	PRIME POWER			STANDBY POWER		
1. VISUAL INSPECTION		SAT			SAT		
2. REGULATOR INPUT		VOLTAGE		CURRENT	VOLTAGE		CURRENT
		INITIAL	ADJUSTED		INITIAL	ADJUSTED	
PHASE A		245		*	260		125
PHASE B		245		*	260		125
PHASE C		245		*	260		125
NEUTRAL							
3. REGULATOR OUTPUT							
PHASE A							
PHASE B							
PHASE C							
NEUTRAL							

GENERATOR	MANUFACTURER: Caterpillar	TYPE: A33TF	SERIAL NUMBER: 37B2937
	CAPACITY: 150KW	FREQUENCY: 60 Hz	LOAD: 65KW
AUTOMATIC CHANGEOVER	MANUFACTURER: Westinghouse	TYPE: Auto	CHANGEOVER INTERVAL: 8 sec

VOLTAGE REGULATOR RESPONSE

VOLTAGE REGULATOR	SPECIFICATION	AS FOUND	ADJUSTED TO:		TIME TO ADJUST
			MANUALLY	AUTOMATIC	
PHASE A					
PHASE B					
PHASE C					

EQUIPMENT GROUNDING:

REMARKS:

* NOTE: Commerical buss was too large to measure with available equipment.

A. C. POWER	DATE March 1978
LOCATION RAPCON	EQUIPMENT & SERIAL NUMBER

CHECK	SPECIFICATIONS	PRIME POWER			STANDBY POWER		
1. VISUAL INSPECTION		SAT			SAT		
2. REGULATOR INPUT		VOLTAGE		CURRENT	VOLTAGE		CURRENT
		INITIAL	ADJUSTED		INITIAL	ADJUSTED	
PHASE A		230		190	220		177
PHASE B		230		190	220		175
PHASE C		230		190	220		175
NEUTRAL							
3. REGULATOR OUTPUT							
PHASE A							
PHASE B							
PHASE C							
NEUTRAL							

GENERATOR	MANUFACTURER Onan	TYPE 1700	SERIAL NUMBER 17-02539
	CAPACITY 175KW	FREQUENCY 60 Hz	LOAD 116KW
AUTOMATIC CHANGEOVER	MANUFACTURER Lake Shore	TYPE Auto	CHANGEOVER INTERVAL 4 sec

VOLTAGE REGULATOR RESPONSE

VOLTAGE REGULATOR	SPECIFICATION	AS FOUND	ADJUSTED TO:		TIME TO ADJUST
			MANUALLY	AUTOMATIC	
PHASE A					
PHASE B					
PHASE C					

EQUIPMENT GROUNDING:

REMARKS:

A. C. POWER	DATE March 1978
LOCATION Transmitter Site	EQUIPMENT & SERIAL NUMBER

CHECK	SPECIFICATIONS	PRIME POWER			STANDBY POWER		
1. VISUAL INSPECTION		SAT			SAT		
2. REGULATOR INPUT		VOLTAGE		CURRENT	VOLTAGE		CURRENT
		INITIAL	ADJUSTED		INITIAL	ADJUSTED	
PHASE A		123		17.5	130		18
PHASE B		124		15	130		18
PHASE C		125		16	130		17
NEUTRAL							
3. REGULATOR OUTPUT							
PHASE A							
PHASE B							
PHASE C							
NEUTRAL							

GENERATOR	MANUFACTURER Buda	TYPE 80C1290	SERIAL NUMBER 65697
	CAPACITY 30KW	FREQUENCY 60 Hz	LOAD 7KW
AUTOMATIC CHANGEOVER	MANUFACTURER Zenith	TYPE Auto	CHANGEOVER INTERVAL * NOTE

VOLTAGE REGULATOR RESPONSE

VOLTAGE REGULATOR	SPECIFICATION	AS FOUND	ADJUSTED TO:		TIME TO ADJUST
			MANUALLY	AUTOMATIC	
PHASE A					
PHASE B					
PHASE C					

EQUIPMENT GROUNDING:

REMARKS:

* NOTE: Automatic changeover unit was awaiting parts and could not be checked.

A. C. POWER	DATE March 1978
LOCATION Receiver Site	EQUIPMENT & SERIAL NUMBER

CHECK	SPECIFICATIONS	PRIME POWER			STANDBY POWER		
1. VISUAL INSPECTION		SAT			SAT		
2. REGULATOR INPUT		VOLTAGE		CURRENT	VOLTAGE		CURRENT
		INITIAL	ADJUSTED		INITIAL	ADJUSTED	
PHASE A		120		5.5	122		5.7
PHASE B							
PHASE C							
NEUTRAL							
3. REGULATOR OUTPUT							
PHASE A							
PHASE B							
PHASE C							
NEUTRAL							

GENERATOR	MANUFACTURER Consolidated Diesel	TYPE EMU-11S	SERIAL NUMBER 65-0056
	CAPACITY 5KW	FREQUENCY 60 Hz	LOAD .8KW
AUTOMATIC CHANGEOVER	MANUFACTURER Consolidated Diesel	TYPE Auto	CHANGEOVER INTERVAL 20 sec

VOLTAGE REGULATOR RESPONSE

VOLTAGE REGULATOR	SPECIFICATION	AS FOUND	ADJUSTED TO:		TIME TO ADJUST
			MANUALLY	AUTOMATIC	
PHASE A					
PHASE B					
PHASE C					

EQUIPMENT GROUNDING:

REMARKS:

TITLE

RSL MEASUREMENT FLIGHT PROFILE

LOCATION
Ellsworth AFB, SD

DATE
March 1978

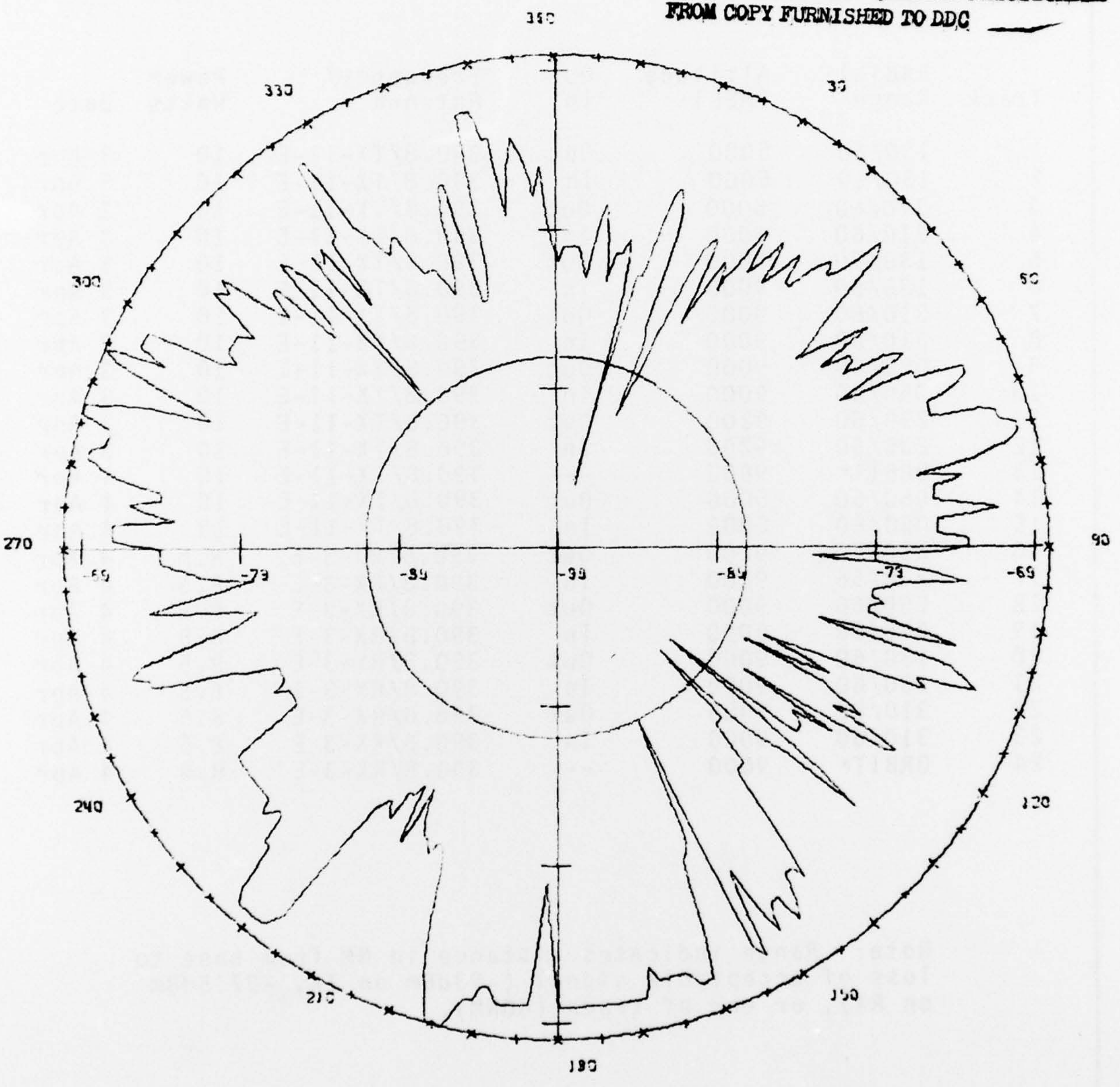
Track	Radial/ Range	Altitude (MSL)	Out In	Frequency/ Antenna	Power Watts	Date
1	130/60	5000	Out	390.8/TX-11-E	10	3 Apr
2	130/60	5000	In	390.8/TX-11-E	10	3 Apr
3	310/60	6000	Out	390.8/TX-11-E	10	3 Apr
4	310/60	6000	In	390.8/TX-11-E	10	3 Apr
5	130/60	9000	Out	390.8/TX-11-E	10	3 Apr
6	130/60	9000	In	390.8/TX-11-E	10	3 Apr
7	310/60	9000	Out	390.8/TX-11-E	10	3 Apr
8	310/60	9000	In	390.8/TX-11-E	10	3 Apr
9	050/60	9000	Out	390.8/TX-11-E	10	3 Apr
10	050/60	9000	In	390.8/TX-11-E	10	3 Apr
11	230/50	9200	Out	390.8/TX-11-E	10	3 Apr
12	230/50	9200	In	390.8/TX-11-E	10	3 Apr
13	ORBIT*	9600	---	390.8/TX-11-E	10	4 Apr
14	050/60	5000	Out	390.8/TX-11-E	10	4 Apr
15	050/60	5000	In	390.8/TX-11-E	10	4 Apr
16	210/55	9200	Out	390.8/RX-3-E	8.5	4 Apr
17	210/56	9200	In	390.8/RX-3-E	8.5	4 Apr
18	050/60	9000	Out	390.8/RX-3-E	8.5	4 Apr
19	050/60	9000	In	390.8/RX-3-E	8.5	4 Apr
20	130/60	9000	Out	390.8/RX-3-E	8.5	4 Apr
21	130/60	9000	In	390.8/RX-3-E	8.5	4 Apr
22	310/60	9000	Out	390.8/RX-3-E	8.5	4 Apr
23	310/60	9000	In	390.8/RX-3-E	8.5	4 Apr
24	ORBIT*	9600	---	390.8/RX-3-E	8.5	4 Apr

Note: Range indicates distance in NM from base to loss of acceptable signal (-93dBm on TX, -97.5dBm on RX), or end of track (60NM).

REMARKS

* NOTE: Indicates a radius of 30 NM.

MEASURED SIGNAL STRENGTH

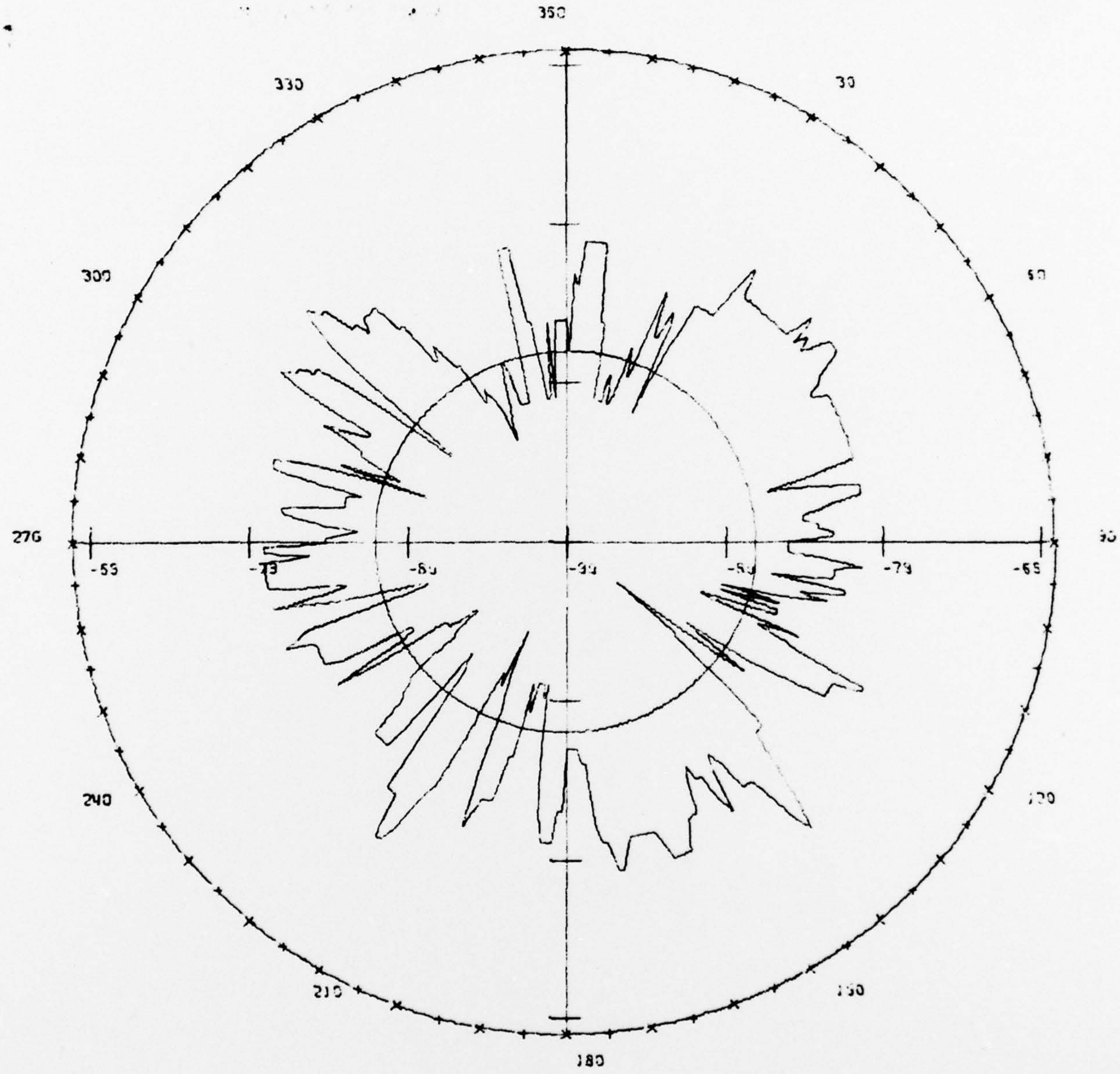


ELLSWORTH AFB
RECEIVER SITE
AN/GRT-22

RANGE 30 NM.
ALTITUDE 9600 FT. MSL
FREQUENCY 390.80 MHZ

VARIATION 13 DEGREES EAST
SCALE 1 INCH = 10 DB
ORIENTED TO MAGNETIC NORTH
-87 DBM = 10 UVOLTS
4 APR 78

MEASURED SIGNAL STRENGTH



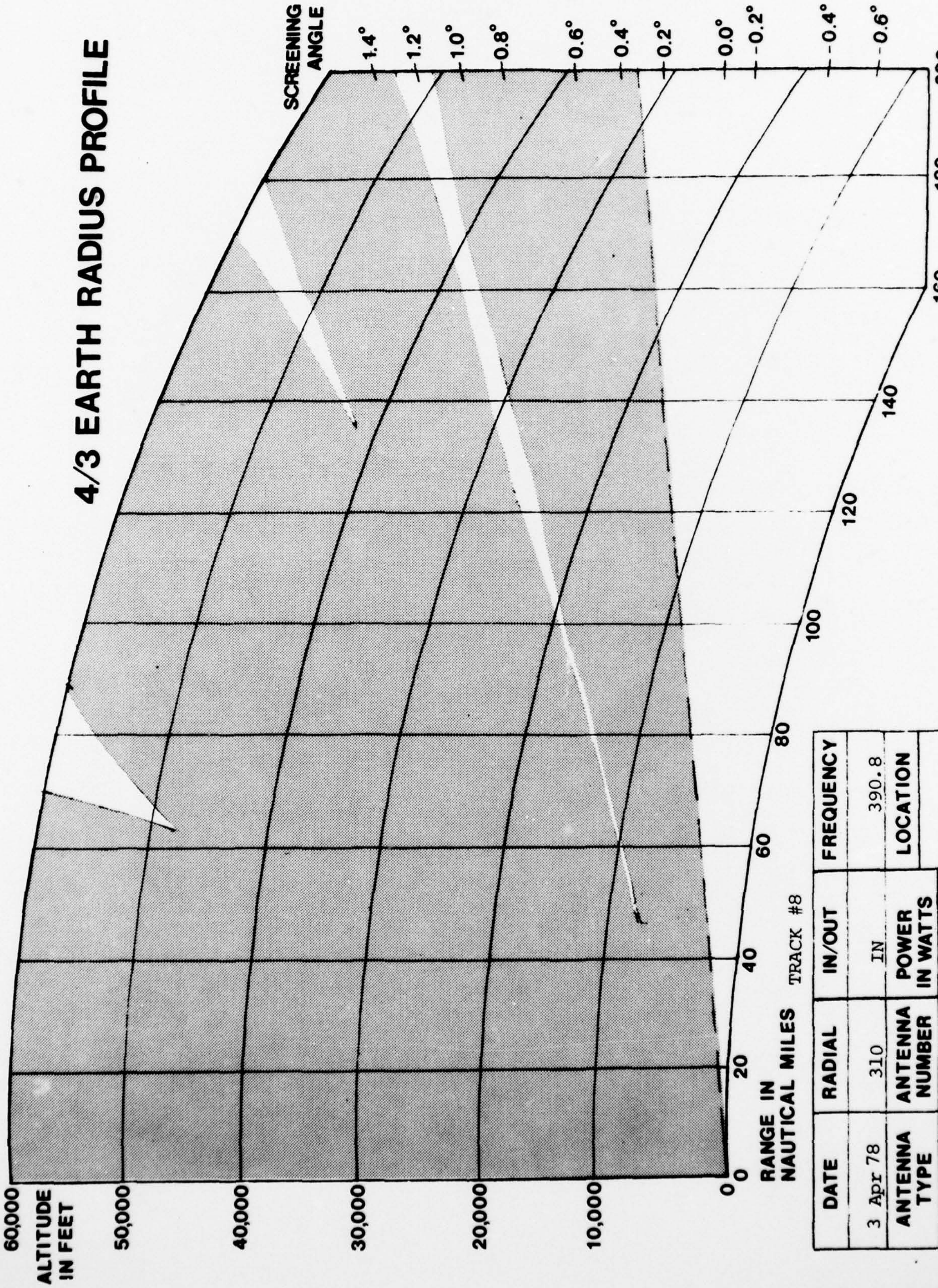
ELLSWORTH AFB
RECEIVER SITE
AN/GRR-24

RANGE 30 NM.
ALTITUDE 9600 FT. MSL
FREQUENCY 390.80 MHZ

VARIATION 13 DEGREES EAST
SCALE 1 INCH = 10 DB
ORIENTED TO MAGNETIC NORTH
-87 DBM = 10 UVOLTS
4 APR 77

TAB: F-2-2

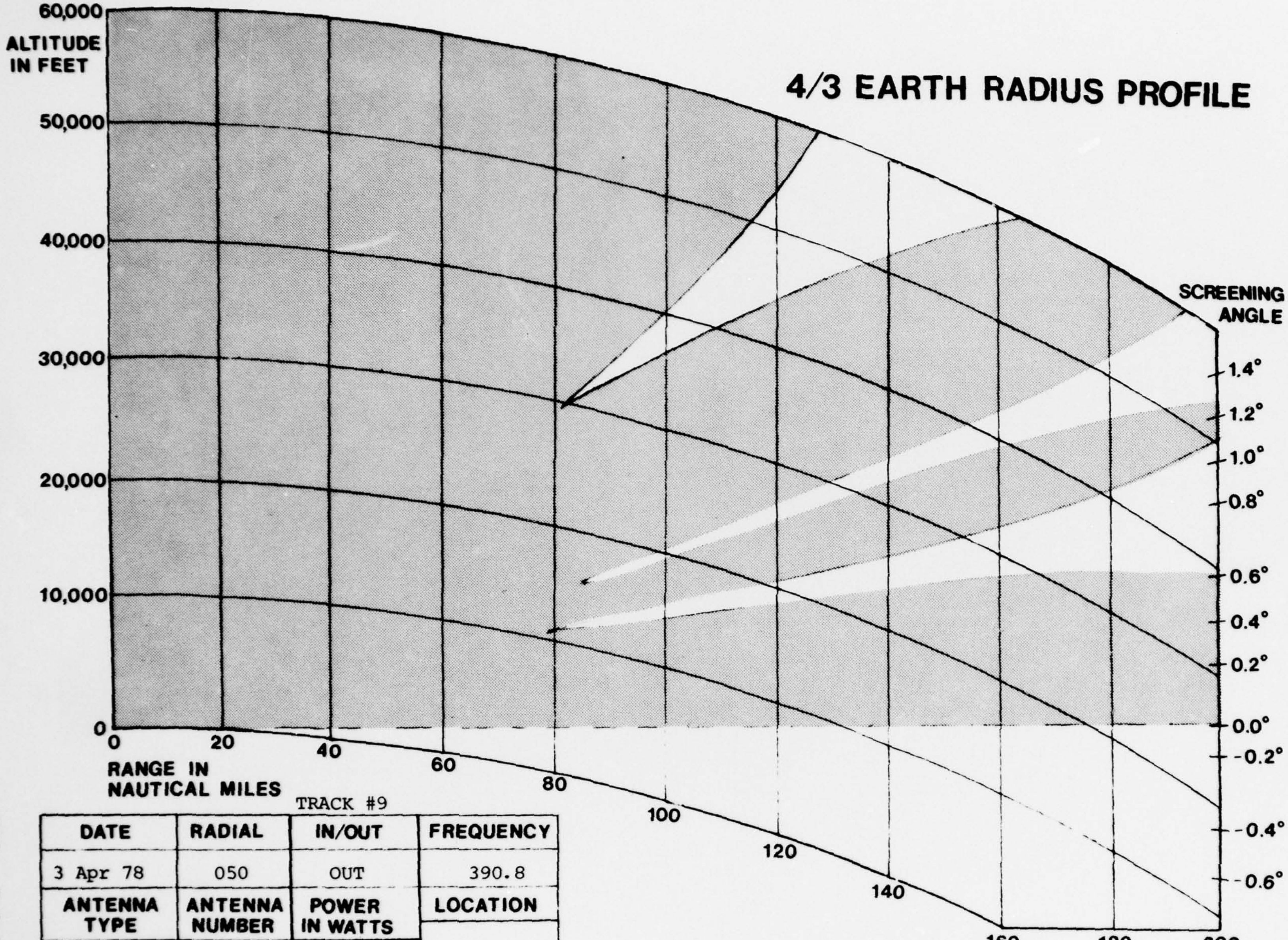
RADIATION PATTERN (-93.0 dBm REFERENCE)



DATE	RADIAL	IN/OUT	FREQUENCY
3 Apr 78	310	IN	390.8
ANTENNA TYPE	**ANTENNA NUMBER**	**POWER IN WATTS**	**LOCATION**
AT-197	11E	10	TX Site

RADIATION PATTERN (-93.0 dBm REFERENCE)

4/3 EARTH RADIUS PROFILE

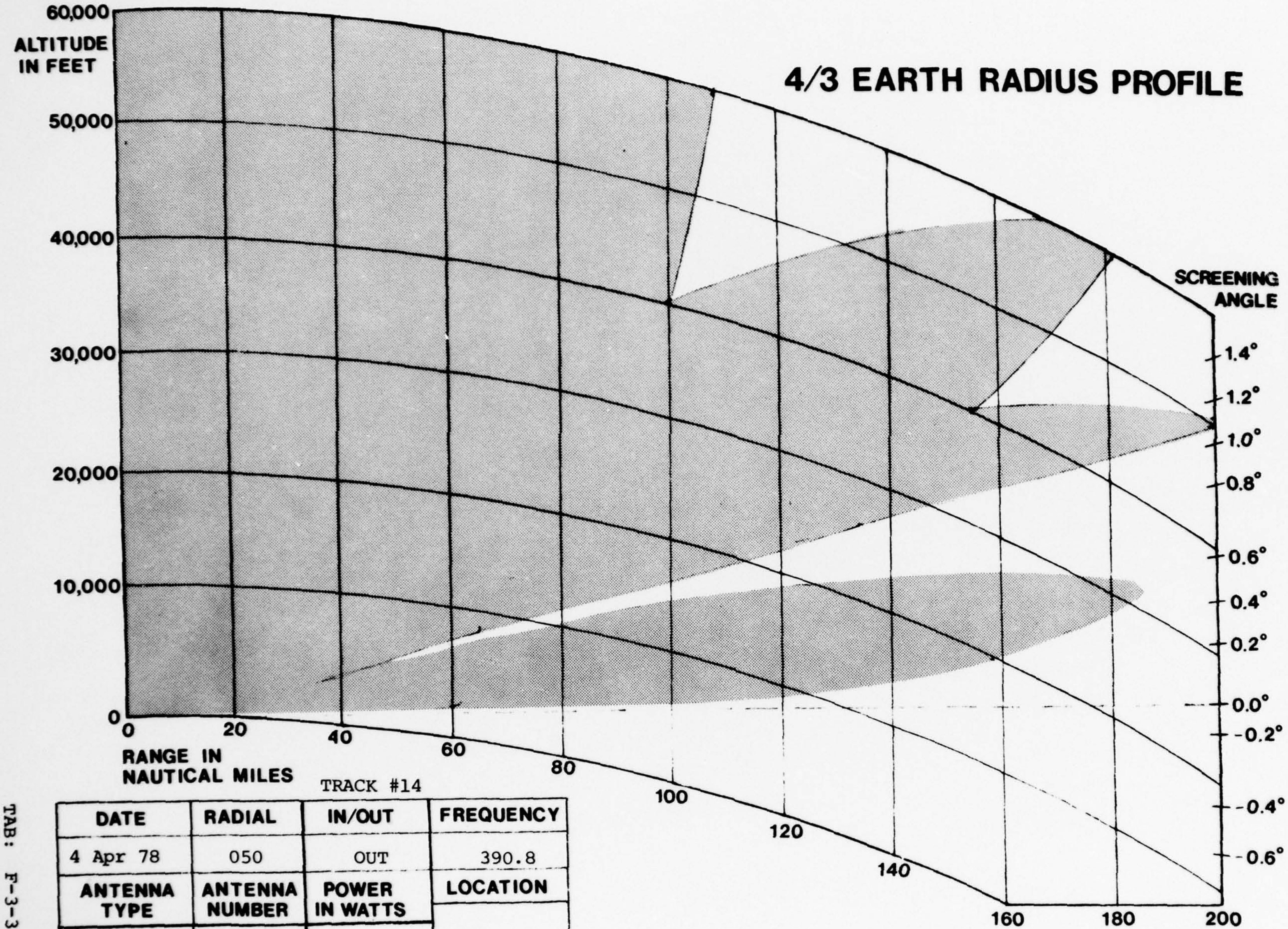


TRACK #9

DATE	RADIAL	IN/OUT	FREQUENCY
3 Apr 78	050	OUT	390.8
ANTENNA TYPE	**ANTENNA NUMBER**	**POWER IN WATTS**	**LOCATION**
AT-197	11E	10	TX Site

RADIATION PATTERN (-93.0 dBm REFERENCE)

4/3 EARTH RADIUS PROFILE

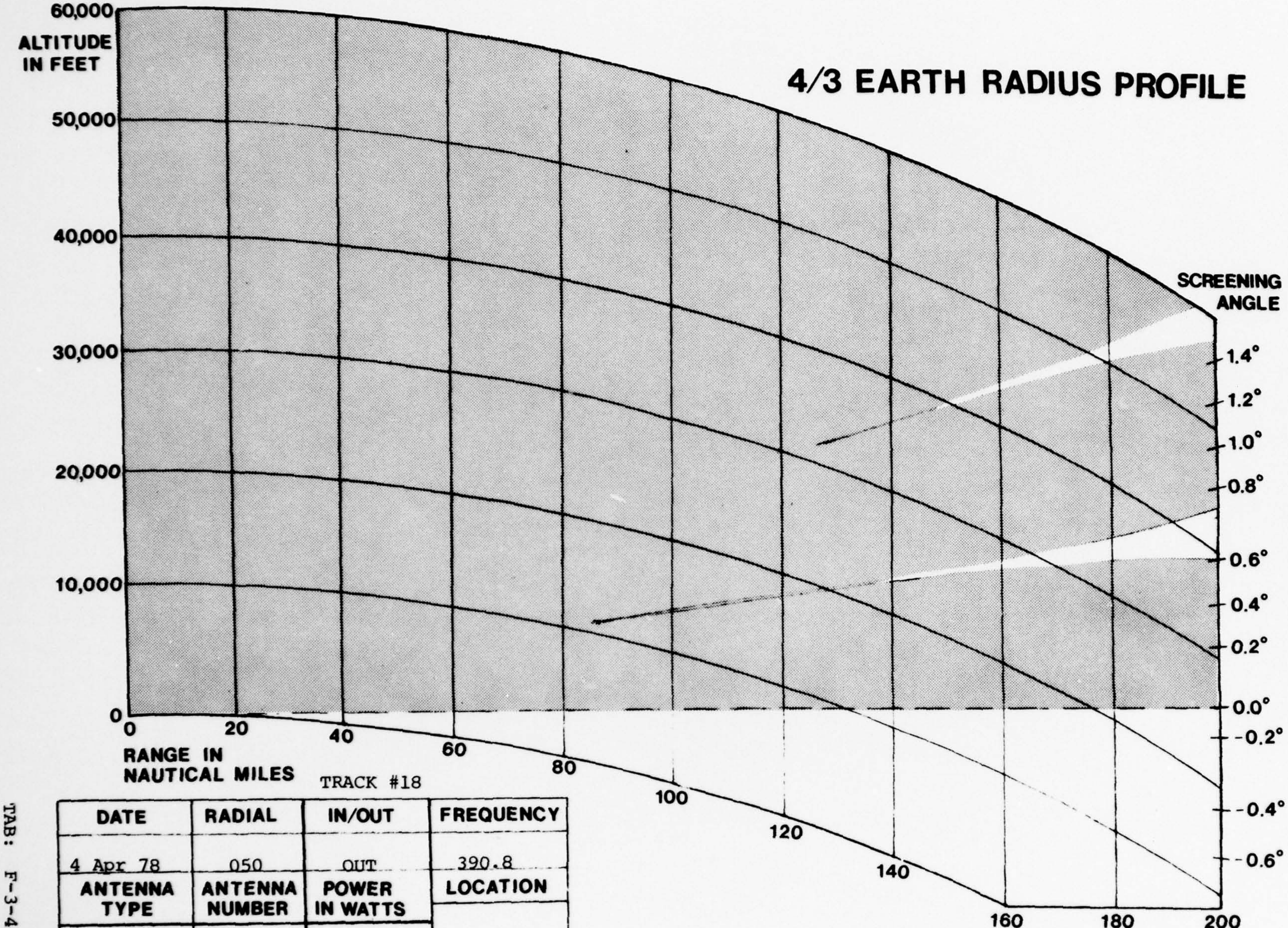


TRACK #14

DATE	RADIAL	IN/OUT	FREQUENCY
4 Apr 78	050	OUT	390.8
ANTENNA TYPE	ANTENNA NUMBER	POWER IN WATTS	LOCATION
AT-197	11E	10	TX Site

RADIATION PATTERN (-97.5 dBm REFERENCE)

4/3 EARTH RADIUS PROFILE

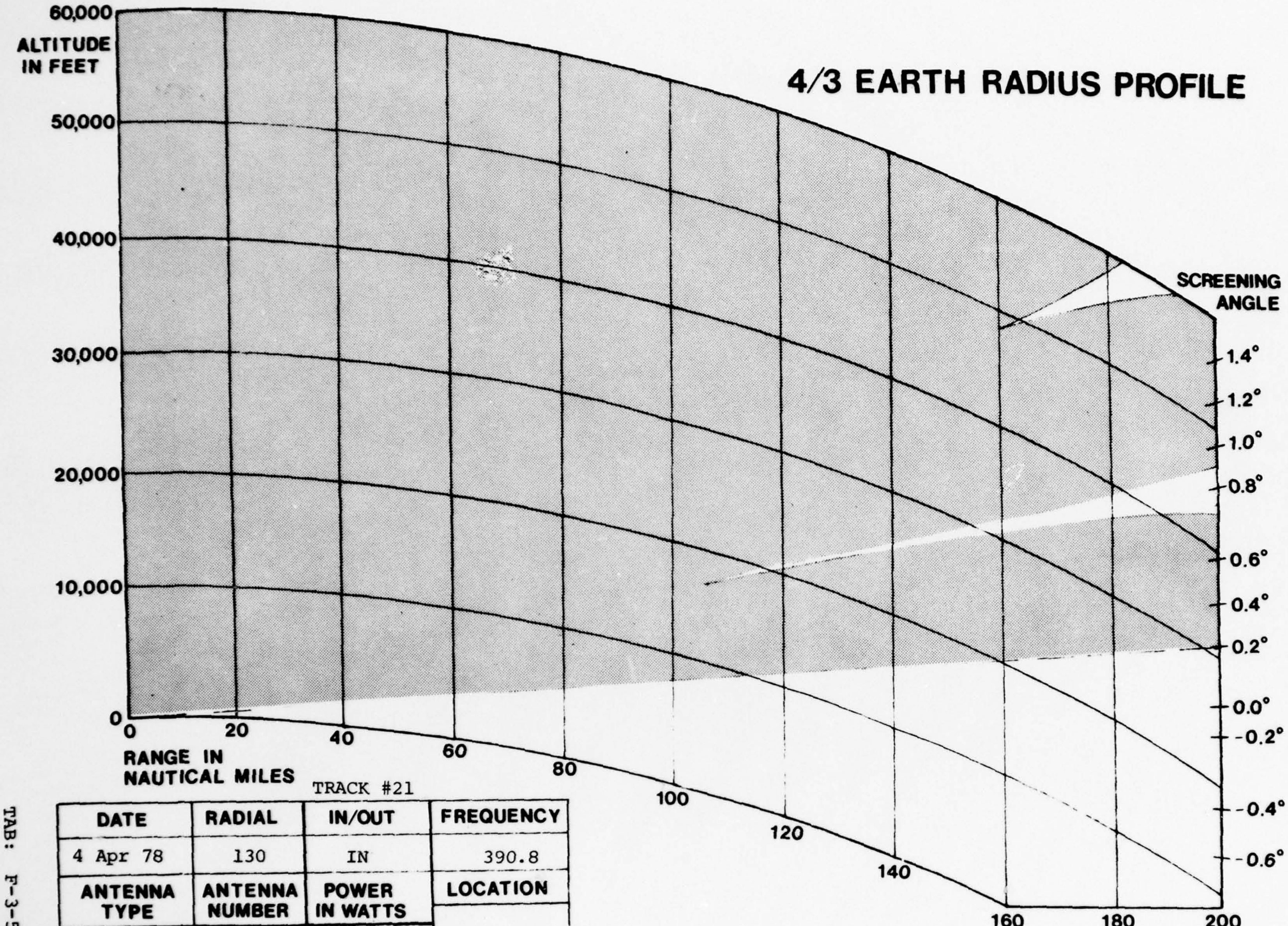


TRACK #18

DATE	RADIAL	IN/OUT	FREQUENCY
4 Apr 78	050	OUT	390.8
ANTENNA TYPE	**ANTENNA NUMBER**	**POWER IN WATTS**	**LOCATION**
AT-197	3E	8.5	RX Site

4/3 EARTH RADIUS PROFILE

RADIATION PATTERN (-97.5 dBm REFERENCE)



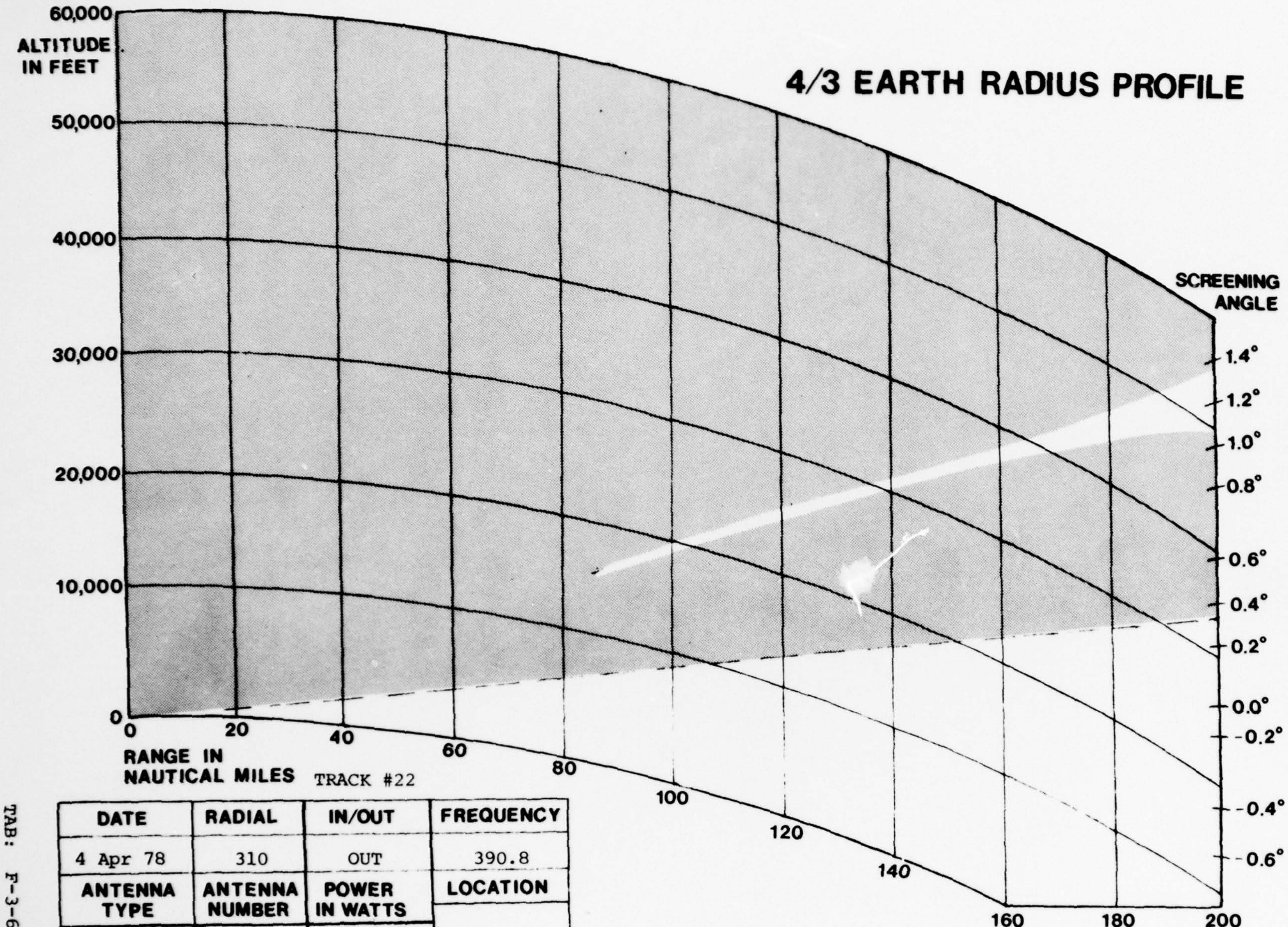
TRACK #21

DATE	RADIAL	IN/OUT	FREQUENCY
4 Apr 78	130	IN	390.8
ANTENNA TYPE	**ANTENNA NUMBER**	**POWER IN WATTS**	**LOCATION**
AT-197	3E	8.5	RX Site

TAB: F-3-5

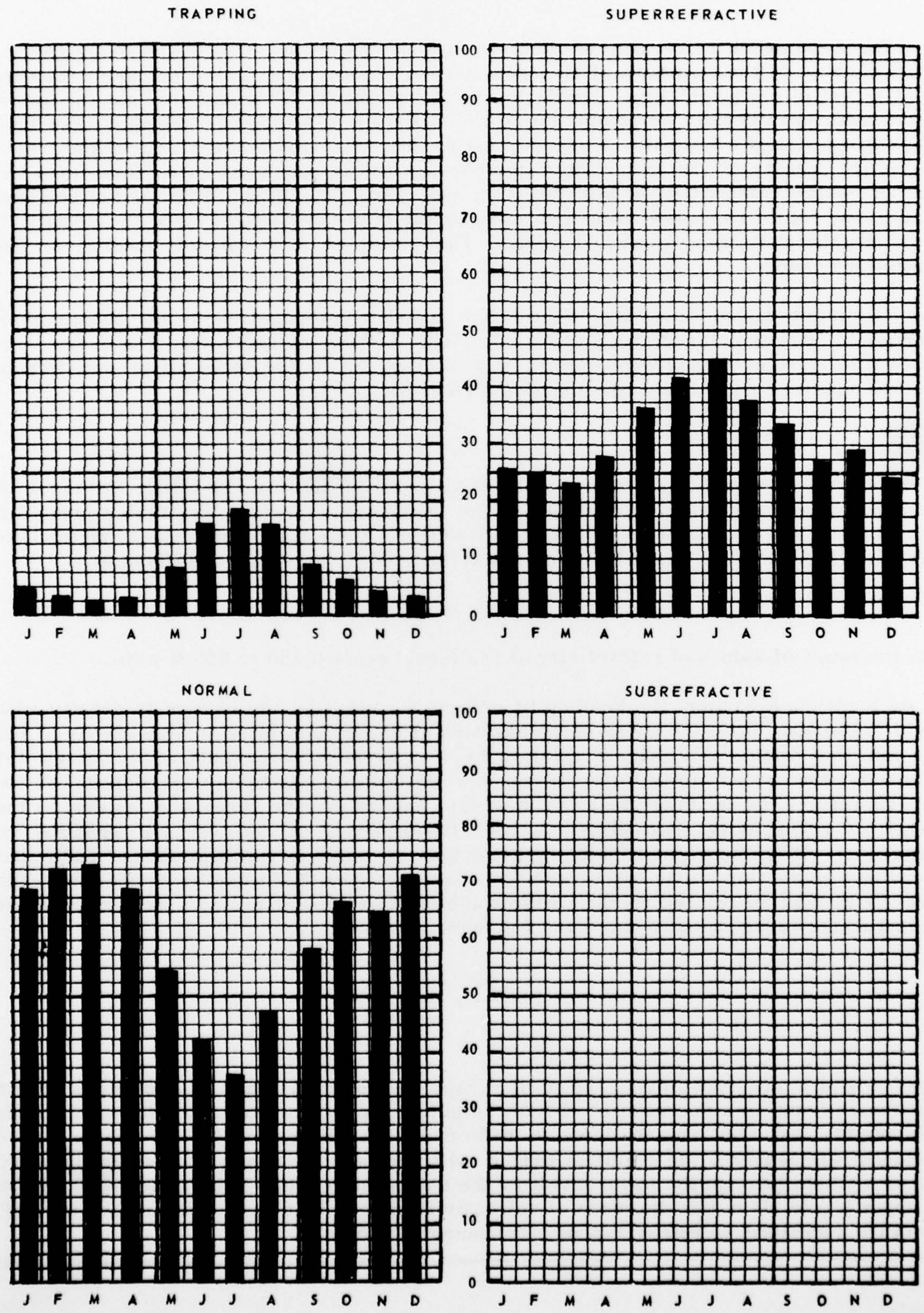
RADIATION PATTERN (-97.5 dBm REFERENCE)

4/3 EARTH RADIUS PROFILE



DATE	RADIAL	IN/OUT	FREQUENCY
4 Apr 78	310	OUT	390.8
ANTENNA TYPE	**ANTENNA NUMBER**	**POWER IN WATTS**	**LOCATION**
AT-197	3E	8.5	RX Site

FREQUENCY OF REFRACTIVE CONDITIONS IN PERCENT	NAME OF BASE Ellsworth AFB, SD



TITLE

REFRACTIVE THEORY AND DEFINITIONS

1. The bending or refraction of electromagnetic energy as it passes through the air occurs because of the structure of the troposphere. Energy propagated through a vacuum would travel in a straight line. Similarly, energy transmitted through any gas (or liquid) that is uniform in density perpendicular to the direction in which the energy is traveling, will follow a straight line path. However, due to the physical characteristics of the troposphere, the density of the troposphere decreases with increasing height. Therefore, the front of energy transmitted at low elevation angles will be subject to refractive bending. Usually, the top of the wave front will move faster than the bottom, since the density of the atmosphere decreases with height. The result is a downward bending of the transmitted energy.

2. The number that describes the relative speed of propagation in any substance is referred to as the index of refraction (n). It is defined as the ratio of the speed of propagation of electromagnetic energy in a vacuum (c) to the speed of propagation of electromagnetic energy in the medium in question (v):

$$n = \frac{c}{v}$$

Within the wavelength band from 1 cm (30 GHz) to 10 meters (30 MHz), the index of refraction does not change appreciably as the frequency changes. The typical range of values of n at sea level is from 1.000250 to 1.000450. Since these numbers are difficult to work with, a "scaled-up" quantity called refractivity (N) is used, and is defined as

$$N = (n - 1)\,10^6$$

Thus the range of values of refractivity at sea level becomes 250 to 450 N-units.

3. As mentioned earlier, the bending of energy is caused by the change in density with height in the air. Since the speed of propagation of energy is related to the density of the air, and the refractivity (N) is related to the speed of propagation of energy (by definition), then refractivity in the troposphere is directly related to the density of the air. Therefore, the bending of electromagnetic energy may be thought of as due to the change of refractivity with height in the troposphere, or the vertical gradient of refractivity. It is important to note that it is not the value of N at a particular point that determines refraction but it is the gradient of refractivity that must be considered. The refractivity may be related to the meterorological variables of pressure (p), temperature (T), and water vapor pressure (e) by the following equation:

$$N = \frac{Ap}{T} + \frac{Be}{T^2}$$

where A and B are constants. The normal rapid decrease of p and e with height in the troposphere leads to a decrease of N with height. Temperature usually decreases slowly with height, and this has an opposite effect on the change of N. In the so-called "standard" atmosphere, the result is that N will decrease by about 12 N-units per 1000 feet of altitude through the lower levels of the troposphere, and 6 N-units per 1000 feet in the upper levels. It is this decrease of refractivity with height that leads to the "normal" downward curvature, or refraction, of electromagnetic energy.

TITLE

REFRACTIVE THEORY AND DEFINITIONS

4. In the "real" troposphere all is not so simple. The temperature and water vapor pressure may vary in any manner, while atmospheric pressure will continue to decrease with height. This seemingly random variation of the meteorological terms will lead to unusual changes in refractivity with height. Refractivity may decrease more than in the "standard" troposphere, causing more pronounced bending of electromagnetic energy. On the other hand, refractivity may actually increase with height, which may result in an upward curvature of a radio/radar beam (opposite the curvature of the earth). The propagation of electromagnetic energy along a path that is different from the usual or expected path is known as "anomalous propagation" (AP). The refraction that results under various AP conditions is referred to as either subrefraction, superrefraction, or trapping (ducting). These refractive conditions, the effects on electromagnetic energy presented as a single ray, and the gradients of refractivity that may cause them are defined below:

a. Subrefraction: Ray curvature is upward. Radio/radar ranges are significantly reduced. The occurrence is quite rare. The gradient of refractivity is equal to or greater than 0 N-units/1000 feet (average "standard" value is - 12 N-units/1000 feet).

b. Normal refraction: Ray curvature is downward but not as much as the curvature of the earth. Radio/radar performance is generally undisturbed, and the occurrence is frequent. The gradient of refractivity is less than 0 N-units/100 feet and greater than - 24 N-units/100 feet.

c. Superrefraction: Ray curvature is downward, more sharply than normal, but not as much as the curvature of the earth's surface. Radio/radar ranges may be significantly extended; the occurrence is frequent. The gradient of refractivity is greater than -48 N-units/100 feet and less than or equal to -24 N-units/1000 feet.

d. Trapping: Extreme superrefraction, with downward curvature equal to or greater than the curvature of the earth's surface. Radio/radar performance is greatly disturbed, ranges are greatly extended, holes in coverage may appear; occurrence is not normally frequent. The gradient of refractivity is less than or equal to -48 N-units/1000 feet.

5. For an understanding of refractive effects on the system being evaluated, refer to AFCS Pamphlet 100-79.